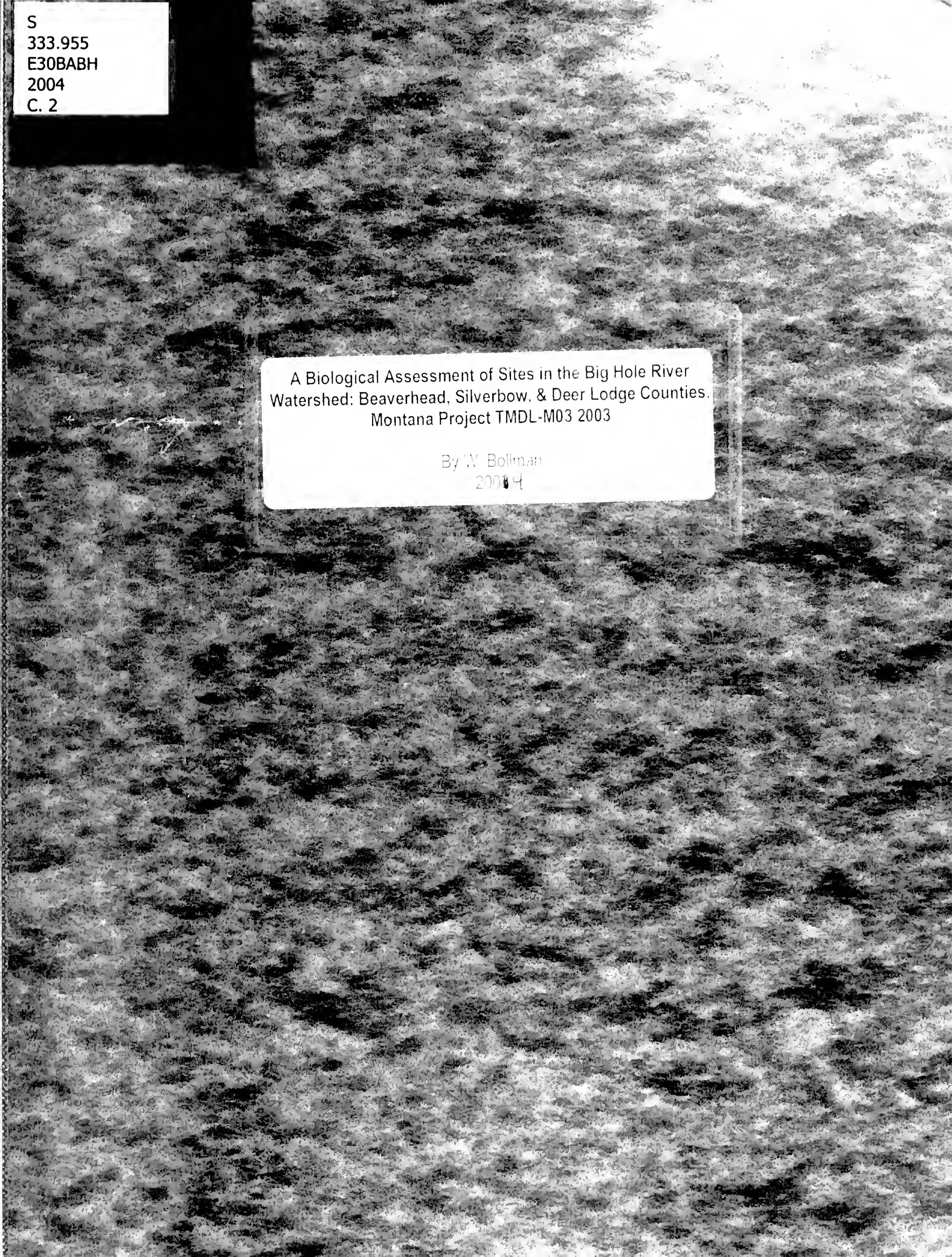

A Biological Assessment of Sites in the Big Hole River Watershed: Beaverhead, Silverbow, & Deer Lodge Counties, Montana Project TMDL-M03 2003

By W. Bollman
2004

A BIOLOGICAL ASSESSMENT OF SITES IN THE BIG HOLE RIVER WATERSHED: BEAVERHEAD, SILVER BOW, & DEER LODGE COUNTIES, MONTANA

Project TMDL-M03

2003

A report to

The Montana Department of Environmental Quality
Planning, Prevention and Assistance Division
Helena, Montana
Al Nixon, Project Officer

by

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles, and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in 2003 from 40 sites in the Big Hole River Watershed, in the Beaverhead, Silver Bow, and Deer Lodge Counties of Montana. Some sites in this study lie within the Montana Valley and Foothill Prairies (MVFP) ecoregion (Woods et al. 1999) and others in the Northern Rockies ecoregion.

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples.

METHODS

Samples were collected in 2003 by Montana DEQ personnel. Sample designations and site locations are indicated in Tables 1a and 1b, and approximate locations are illustrated in Figure 1. The site selection and sampling method employed were those recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses.

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

Table 1a. Sample designations and locations. Sites are listed in upstream-to-downstream order relative to the Big Hole River, and within specific tributary watersheds. Big Hole River Watershed, 2003. (Longitude for Fox Creek (FOX02) was apparently reported erroneously. The appropriate longitude is reported in italics in this table.)

Site ID	Station ID	Activity ID	Location Description	Sample date	Latitude	Longitude
PINE01	M03PINEC01	03-U316-M	PINE CREEK U/S USFS BOUNDARY	7/15/03	45-12-17	113-20-19
PINE02	M03PINEC02	03-U315-M	PINE CREEK U/S MOUTH OF ANDRUS CR	7/15/03	45-14-34	113-20-49
FOX01	M03FOXC01	03-U318-M	FOX CREEK U/S USFS BOUNDARY	7/15/03	45-14-55	113-16-17
FOX02	M03FOXC02	03-U317-M	FOX CREEK ABOVE MOUTH @ ANDRUS CR	7/15/03	45-16-19	*113-21-31*
WRMS01	M03WRMSC01	03-U308-M	WARM SPRINGS CREEK ON USFS	6/21/03	45-27-16	113-17-58
WRMS02	M03WRMSC02	03-U309-M	WARM SPRINGS CREEK D/S OF HWY 278	6/21/03	45-22-5	113-24-48
FRAN01	M03FRANC01	03-U330-M	FRANCIS CREEK D/S OF SAND CR	7/24/03	45-33-52	113-24-45
FRAN02	M03FRANC02	03-U331-M	FRANCIS CREEK ABOVE MOUTH OF SANLEY CR	7/24/03	45-35-46	113-26-17
SWMP01	M03SWMPC01	03-U306-M	SWAMP CREEK U/S OF HWY 43	6/20/03	45-37-46	113-30-9
SWMP02	M03SWMPC02	03-U307-M	SWAMP CREEK U/S OF LOWER NF RD	6/20/03	45-39-32	113-28-11
BGHNF01	M03BGHNF01	03-U311-M	BIG HOLE NF AT BIG HOLE BATTLEFIELD	7/10/03	45-38-39	113-39-7
BGHNF02	M03BGHNF02	03-U310-M	BIG HOLE NF U/S OF BRIDGE @ LOWER NF RD	7/9/03	45-42-19	113-27-34
MCVY01	M03MCVYC01	03-U304-M	MCVEY CREEK UPPER BOUNDARY STATE LANDS	6/19/03	45-40-36	113-23-12
MCVY02	M03MCVYC02	03-U305-M	MCVEY CREEK U/S OF HWY 43	6/20/03	45-42-0	113-25-24
DOLT01	M03DOLTC01	03-U302-M	DOOLITTLE CREEK @ GAUGE STATION	6/19/03	45-43-4	113-20-43
DOLT02	M03DOLTC02	03-U303-M	DOOLITTLE CREEK U/S OF HWY 43	6/19/03	45-44-16	113-22-46
SWLG01	M03SWLGC01	03-U360-M	SAWLOG CREEK	9/13/03	45-50-16	113-15-0
FSHT01	M03FSHTC01	03-U319-M	FISHTRAP CREEK D/S OF WF, MF, EF FISHTRAP	7/16/03	45-53-13	113-15-38
FSHT02	M03FSHTC02	03-U320-M	FISHTRAP CREEK D/S OF BRIDGE @ HWY 43	7/16/03	45-52-12	113-13-39
LMCH01	M03LMCHC01	03-U321-M	LAMARCHE CREEK U/S USFS BOUNDARY	7/16/03	45-54-39	113-13-2
LMCH02	M03LMCHC02	03-U322-M	LAMARCHE CREEK D/S OF BRIDGE @ HWY 43	7/16/03	45-52-42	113-11-55

Table 1b. Sample designations and locations. Sites are listed in upstream-to-downstream order relative to the Big Hole River, and within specific tributary watersheds. Big Hole River Watershed, 2003.

Site ID	Station ID	Activity ID	Location Description	Sample date	Latitude	Longitude
ELKH01	M03ELKHC01	03-U328-M	ELKHORN CREEK D/S OF COOLIDGE	7/23/03	45-30-1	113-2-38
ELKH02	M03ELKHC02	03-U329-M	ELKHORN CREEK ABOVE JACOBSON CR	7/23/03	45-31-38	113-3-41
GOLD01	M03GOLDC01	03-U312-M	GOLD CREEK U/S OF FS RD 484	7/10/03	45-36-56	113-5-3
GOLD02	M03GOLDC02	03-U313-M	GOLD CREEK U/S OF MOUTH OF WISE R	7/10/03	45-36-51	113-5-19
DLNO01	M03DLNOC01	03-U325-M	DELANO CREEK U/S OF CULVERT ON FS RD 83	7/17/03	45-54-39	112-51-58
DLNO02	M03DLNOC02	03-U323-M	DELANO CREEK U/S OF MOUTH OF JERRY CR	7/17/03	45-54-20	112-51-21
JERR01	M03JERRC01	03-U314-M	JERRY CREEK	7/10/03	45-53-46	112-51-10
CHRG01	M03CHRGC01	03-U327-M	CHARCOAL GULCH CREEK	7/23/03	45-46-57	112-47-15
DIVD01	M03DIVDC01	03-U332-M	DIVIDE CREEK D/S INTERSTATE EXIT 111	7/30/03	45-51-31	112-40-28
DIVD02	M03DIVDC02	03-U333-M	DIVIDE CREEK U/S OF HWY 43	7/30/03	45-45-4	112-44-55
MCLN01	M03MCLNC01	03-U336-M	MACLEAN CREEK	7/31/03	45-44-29	112-40-7
SOAP01	M03SOAPC01	03-U334-M	SOAP CREEK U/S OF LEFT FORK SOAP CR	7/30/03	45-42-13	112-34-14
SOAP02	M03SOAPC02	03-U335-M	SOAP CREEK U/S OF HWY 15	7/30/03	45-41-13	112-39-2
CAMP03	M03CAMPC03	03-U364-M	CAMP CREEK U/S OF CONFLUENCE OF WICKUP	9/15/03	45-41-57	112-31-58
CAMP02	M03CAMPC02	03-U363-M	CAMP CREEK EAST OF I-15	9/15/03	45-38-51	112-38-9
CAMP01	M03CAMPC01	03-U362-M	CAMP CREEK U/S FROM MOUTH	9/14/03	45-37-31	112-41-11
GROS01	M03C01	03-U357-M	GROSE CREEK	9/12/03	45-32-54	112-43-41
LOST02	M03LOSTC02	03-U359-M	LOST CREEK 4 MILES FROM COUNTY RD	9/14/03	45-29-29	112-46-41
LOST01	M03LOSTC01	03-U358-M	LOST CREEK WEST OF I-15	9/13/03	45-29-42	112-44-9

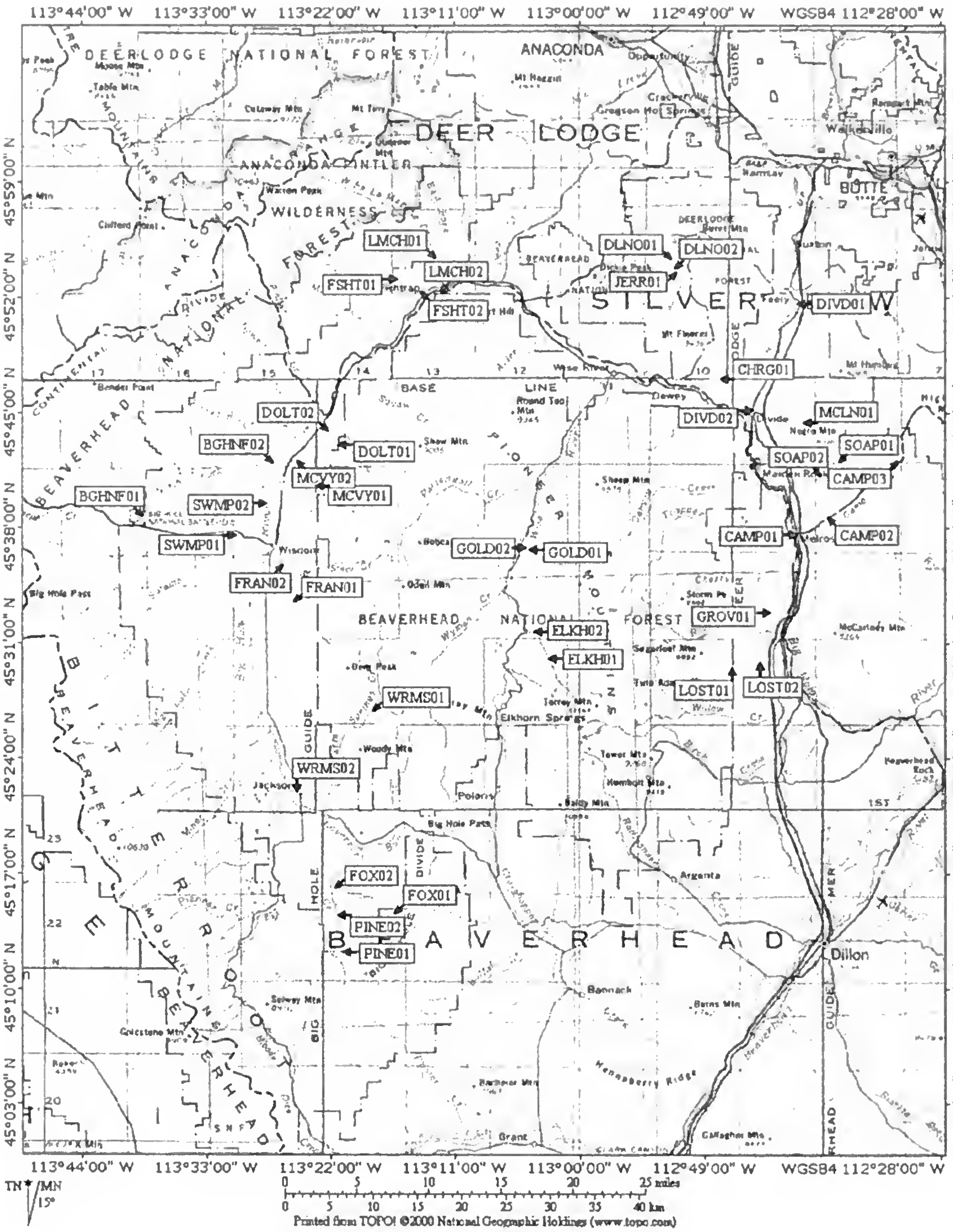


Figure 1. Approximate locations of sampling sites. Big Hole River watershed, 2003.

To assess aquatic invertebrate communities, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998a) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank, and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998a). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics constituting the bioassessment index used for MVFP sites in this study were selected because, both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998a). In addition, they are relevant to the kinds of impacts that are present in the Big Hole River watershed. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998a). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998a).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as

silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. **Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery. The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 2. Metrics and scoring criteria for bioassessment of streams of the Montana Valley and Foothill Prairies ecoregion (Bollman 1998a).

	Score			
Metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 – 35	> 35

Table3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).	
% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).	
% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman 1998b). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998a). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.

- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman 1998b).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman 1998b).

RESULTS

Bioassessment

Figures 2a and 2b summarize bioassessment scores for aquatic invertebrate communities sampled from sites in the Big Hole River watershed. Tables 4a through 4d itemize each contributing metric and show individual metric scores for each site. Tables 3a and 3b above show criteria for impairment classifications (Plafkin et al. 1989) and use-support categories recommended by Montana DEQ (Bukantis 1998).

When this method is applied to these data, scores suggest that 14 sites were essentially non-impaired and fully supported designated uses. These sites were: the upstream sites on Pine Creek (PINE01), Fox Creek (FOX01), Doolittle Creek (DOLT01), LaMarche Creek (LMCH01), Elkhorn Creek (ELKH01), and Camp Creek (CAMP03); all sampled sites on Lost Creek (LOST01 and LOST02), Gold Creek (GOLD01 and GOLD02), and Delano Creek (DLNO01 and DLNO02); and sites on MacLean Creek (MCLN01), and Charcoal Gulch Creek (CHRG01). Scores indicated slight impairment but full use support at 5 sites. These were the upstream sites on Warmsprings Creek (WRMS01) and Soap Creek (SOAP01), the downstream sites on Fishtrap Creek (FSHT02) and Elkhorn Creek (ELKH02), and the site sampled on Jerry Creek (JERR01). Ten sites scored slight impairment and partial support of designated uses. These were the downstream sites on Pine Creek (PINE02), Fox Creek (FOX02), Warmsprings Creek (WRMS02), Swamp Creek (SWMP02), LaMarche Creek (LMCH02), and Soap Creek (SOAP02); the middle site on Camp Creek (CAMP02); the upper site on Fishtrap Creek (FSHT01); and both sites sampled on the North Fork Big Hole River (BGHNF01 and BGHNF02). Moderate impairment and partial use support was indicated at 7 sites. These were the upper sites on Francis Creek (FRAN01), Swamp Creek (SWMP01); downstream sites on Doolittle Creek (DOLT02) and Divide Creek (DIVD02), both sampled sites on McVey Creek (MCVY01 and MCVY02); and the site on Grose Creek (GROS01). Three sites were moderately impaired and did not support uses. These were the downstream sites on Francis Creek (FRAN02) and Camp Creek (CAMP01), and the site on Sawlog Creek (SWLG01). The upper site on Divide Creek (DIVD01) was severely impaired and did not support designated uses.

Figure 2a. Comparison of total bioassessment scores (reported as percent of maximum score) for 21 sites in the Big Hole River watershed. 2003. The revised bioassessment method (Bollman 1998) was used to calculate scores.

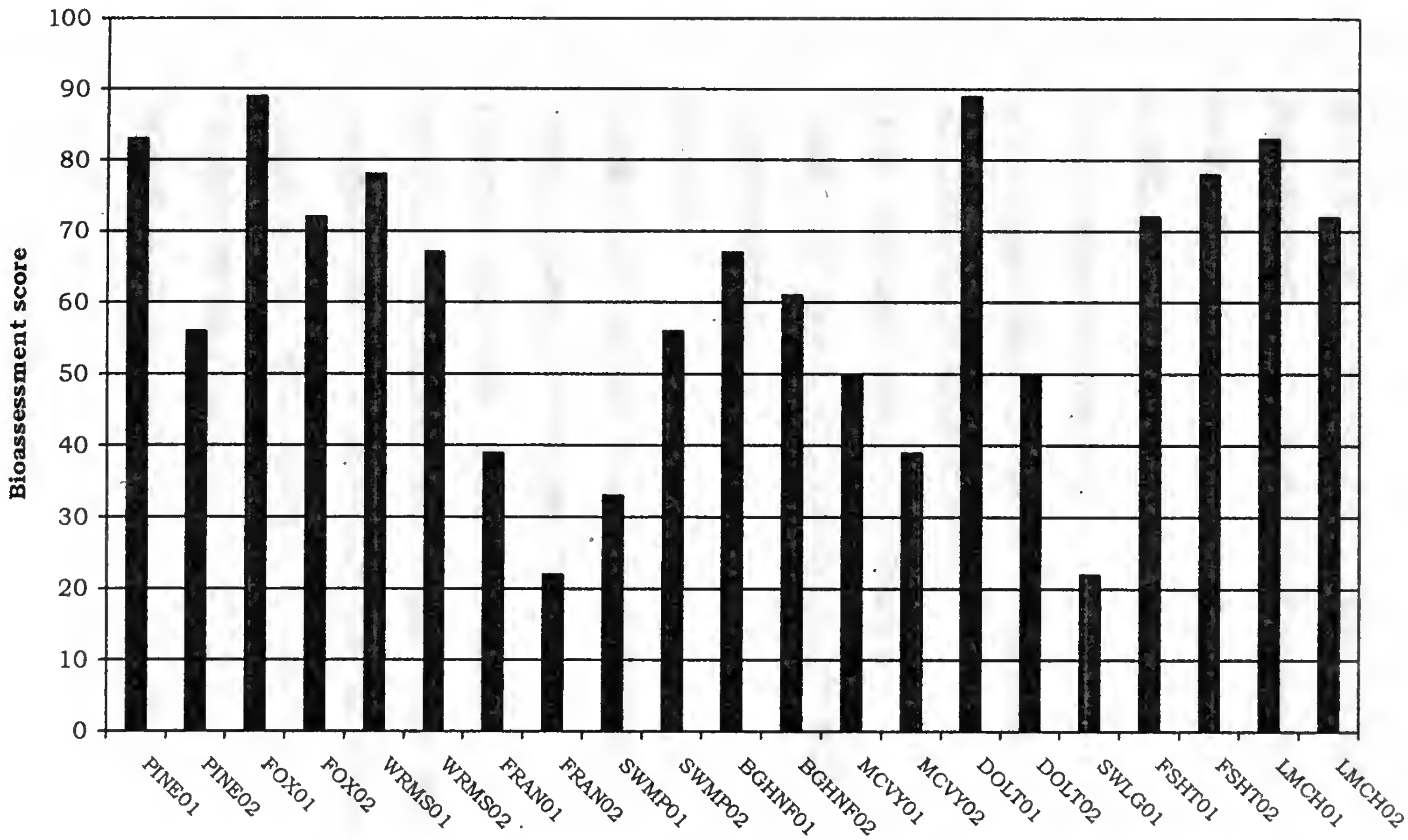


Figure 2b. Comparison of total bioassessment scores (reported as percent of maximum score) for 19 sites in the Big Hole River watershed. 2003. The revised bioassessment method (Bollman 1998) was used to calculate scores.

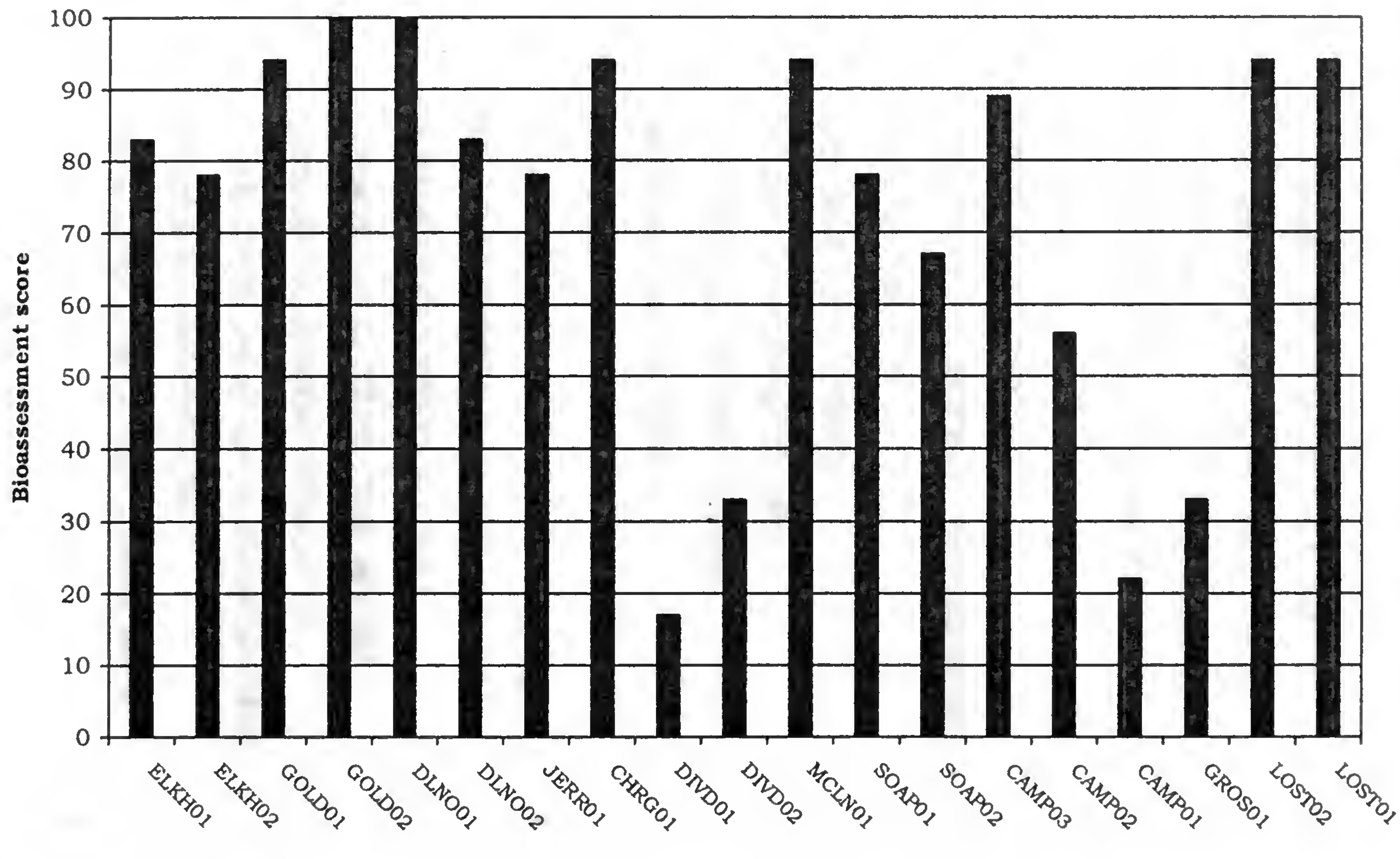


Table 4a. Metric values, scores, and bioassessments for 10 sites in the Big Hole River watershed 2003. Site locations are given in Table 1. The revised bioassessment method (Bollman 1998) was used to calculate scores.

	SITES									
METRICS	**PINE 01**	**PINE 02**	**FOX 01**	**FOX 02**	**WRMS 01**	**WRMS 02**	**FRAN 01**	**FRAN 02**	**SWMP 01**	**SWMP 02**
	METRIC VALUES									
Ephemeroptera richness	9	5	8	8	12	10	4	3	4	7
Plecoptera richness	4	2	6	4	3	3	0	0	0	0
Trichoptera richness	5	10	6	10	9	9	0	2	3	10
Number of sensitive taxa	1	2	4	3	7	2	1	0	0	0
% filterers	7.77	30.41	9.81	11.85	17.21	6.84	3.52	7.96	7.67	2.05
% tolerant taxa	1.06	11.11	8.49	22.87	6.82	43.87	33.72	46.02	64.20	30.72
	METRIC SCORES									
Ephemeroptera richness	3	2	3	3	3	3	2	1	2	3
Plecoptera richness	3	2	3	3	2	2	0	0	0	0
Trichoptera richness	3	3	3	3	3	3	0	1	2	3
Number of sensitive taxa	1	2	3	2	3	2	1	0	0	0
% filterers	2	0	2	1	1	2	3	2	2	3
% tolerant taxa	3	1	2	1	2	0	1	0	0	1
TOTAL SCORE (max.=18)	15	10	16	13	14	12	7	4	6	10
PERCENT OF MAX.	**83%**	**56%**	**89%**	**72%**	**78%**	**67%**	**39%**	**22%**	**33%**	**56%**
Impairment classification*	**NON**	**SLI**	**NON**	**SLI**	**SLI**	**SLI**	**MOD**	**MOD**	**MOD**	**SLI**
USE SUPPORT †	**FULL**	**PART**	**FULL**	**PART**	**FULL**	**PART**	**PART**	**NON**	**PART**	**PART**

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

Table 4b. Metric values, scores, and bioassessments for 11 sites in the Big Hole River watershed 2003. Site locations are given in Table 1. The revised bioassessment method (Bollman 1998) was used to calculate scores. Impairment classifications and Use Support designations indicated with parentheses are associated with small sample size and so are unreliable.

METRICS	BGHNF 01	BGHNF 02	MCVY 01	MCVY 02	DOLT 01	DOLT 02	SWLG 01	FSHT 01	FSHT 02	LMCH 01	LMCH 02
METRIC VALUES											
Ephemeroptera richness	12	12	4	4	9	4	0	9	9	11	12
Plecoptera richness	3	2	2	0	6	2	0	3	6	5	3
Trichoptera richness	7	4	1	4	9	2	0	8	10	8	9
Number of sensitive taxa	2	2	1	0	13	1	0	2	3	3	2
% filterers	22.08	12.57	4.55	7.99	5.88	12.50	0	7.14	8.68	12.08	13.95
% tolerant taxa	23.05	28.14	18.18	18.21	9.80	9.38	20.00	11.18	12.57	1.51	5.34
METRIC SCORES											
Ephemeroptera richness	3	3	2	2	3	2	0	3	3	3	3
Plecoptera richness	2	2	2	0	3	2	0	2	3	3	2
Trichoptera richness	3	2	0	2	3	1	0	3	3	3	3
Number of sensitive taxa	2	2	1	0	3	1	0	2	2	2	2
% filterers	1	1	3	2	2	1	3	2	2	1	1
% tolerant taxa	1	1	1	1	2	2	1	1	1	3	2
TOTAL SCORE (max.=18)	12	11	9	7	16	9	4	13	14	15	13
PERCENT OF MAX.	**67%**	**61%**	**50%**	**39%**	**89%**	**50%**	**22%**	**72%**	**78%**	**83%**	**72%**
Impairment classification*	**SLI**	**SLI**	**(MOD)**	**MOD**	**NON**	**(MOD)**	**MOD**	**SLI**	**SLI**	**NON**	**SLI**
USE SUPPORT †	**PART**	**PART**	**(PART)**	**PART**	**FULL**	**(PART)**	**NON**	**PART**	**FULL**	**FULL**	**PART**

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

† Use support designations: See Table 3a.

Table 4c. Metric values, scores, and bioassessments for 10 sites in the Big Hole River watershed 2003. Site locations are given in Table 1. The revised bioassessment method (Bollman 1998) was used to calculate scores. Impairment classifications and Use Support designations indicated with parentheses are associated with small sample size and so are unreliable.

METRICS	SITES									
	ELKH 01	ELKH 02	GOLD 01	GOLD 02	DLNO 01	DLNO 02	JERR 01	CHRG 01	DIVD 01	DIVD 02
METRIC VALUES										
Ephemeroptera richness	4	2	8	8	11	8	9	5	1	4
Plecoptera richness	3	7	2	5	9	2	2	4	0	0
Trichoptera richness	3	7	8	6	10	2	2	6	1	1
Number of sensitive taxa	5	7	10	8	14	5	3	7	1	1
% filterers	0	15.75	0.31	0.95	0	2.59	0.63	0.55	7.69	1.47
% tolerant taxa	0	1.37	0	0.32	0.29	0.65	0.63	1.10	37.82	41.76
METRIC SCORES										
Ephemeroptera richness	2	1	3	3	3	3	3	2	0	2
Plecoptera richness	2	3	2	3	3	2	2	3	0	0
Trichoptera richness	2	3	3	3	3	1	1	3	0	0
Number of sensitive taxa	3	3	3	3	3	3	2	3	1	1
% filterers	3	1	3	3	3	3	3	3	2	3
% tolerant taxa	3	3	3	3	3	3	3	3	0	0
TOTAL SCORE (max.=18)	15	14	17	18	18	15	14	17	3	6
PERCENT OF MAX.	**83%**	**78%**	**94%**	**100%**	**100%**	**83%**	**78%**	**94%**	**17%**	**33%**
Impairment classification*	**(NON)**	**(SLI)**	**NON**	**NON**	**NON**	**NON**	**SLI**	**(NON)**	**SEV**	**MOD**
USE SUPPORT †	**(FULL)**	**(FULL)**	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**	**(FULL)**	**NON**	**PART**

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

Table 4d. Metric values, scores, and bioassessments for 9 sites in the Big Hole River watershed 2003. Site locations are given in Table 1. The revised bioassessment method (Bollman 1998) was used to calculate scores. Impairment classifications and Use Support designations indicated with parentheses are associated with small sample size and so are unreliable.

METRICS	SITES								
	MCLN 01	SOAP 01	SOAP 02	CAMP 03	CAMP 02	CAMP 01	GROS 01	LOST 02	LOST 01
	METRIC VALUES								
Ephemeroptera richness	4	4	5	11	1	3	1	4	6
Plecoptera richness	6	2	3	5	5	0	1	7	6
Trichoptera richness	5	5	4	8	3	1	4	9	7
Number of sensitive taxa	7	2	3	4	1	1	0	10	3
% filterers	0.63	6.80	0.31	8.03	0	7.28	11.63	0	0.30
% tolerant taxa	0	1.36	22.88	8.86	14.52	33.77	9.59	0.32	0.30
	METRIC SCORES								
Ephemeroptera richness	2	2	2	3	0	1	0	2	3
Plecoptera richness	3	2	2	3	3	0	1	3	3
Trichoptera richness	3	3	2	3	2	0	2	3	3
Number of sensitive taxa	3	2	2	3	1	1	0	3	2
% filterers	3	2	3	2	3	2	1	3	3
% tolerant taxa	3	3	1	2	1	0	2	3	3
TOTAL SCORE (max.=18)	17	14	12	16	10	4	6	17	17
PERCENT OF MAX.	**94%**	**78%**	**67%**	**89%**	**56%**	**22%**	**33%**	**94%**	**94%**
Impairment classification*	**(NON)**	**(SLI)**	**SLI**	**NON**	**SLI**	**MOD**	**MOD**	**NON**	**NON**
USE SUPPORT †	**(FULL)**	**(FULL)**	**PART**	**FULL**	**PART**	**NON**	**PART**	**FULL**	**FULL**

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

Pine Creek

One hundred feet upstream of the USFS boundary, Pine Creek (PINE01) supported at least 9 mayfly taxa; this suggests that water quality was good at this site. The elevated biotic index (4.49) appears to be due to an abundance of midges. Forty-five percent of sampled animals in 13 taxa were chironomids. Thirteen taxa made up the chironomid assemblage. This could indicate some degradation of water quality, perhaps associated with a thermal challenge. A single cold-stenotherm taxon was taken.

Nineteen "clinger" taxa and 5 caddisfly taxa were collected, suggesting that stony substrate habitats were free from sediment deposition. Other instream habitats appear to have been diverse and undisturbed. Forty-one taxa were collected and 10 of these were predators. Stonefly taxa richness (4) was within expectations; this could indicate that reach-scale habitat features such as streambanks and riparian areas were intact and functional. Although 5 semivoltine taxa were represented, none was abundant; there were only 8 long-lived individuals in the sample. This could indicate that there was a recent interruption to long life cycles, such as loss of surface flow, scouring sediment pulses, or toxic inputs. The functional composition of the assemblage included all expected elements. Shredders were abundant, but many of these were midges (*Cricotopus* spp.) that are associated with filamentous algae rather than the expected assemblage of shredders reliant on ample riparian inputs of large organic debris.

At the downstream site on Pine Creek (PINE02), the biotic index value (2.84) was low, but mayfly taxa richness (5) did not meet expectations. Cold stenotherms remained rare; a single taxon was taken in the sample. Although midges were not as abundant as at the upstream site, the chironomid assemblage was diverse; eleven taxa were collected. It seems likely that water temperatures were somewhat warmer than expected in both sampled reaches of Pine Creek. The lower site supported a few taxa that prefer warmer water, such as the caddisflies *Helicopsyche borealis* and *Ochrotrichia* sp.

The "clinger" fauna was exceptionally rich at this location; twenty-three taxa were collected. This finding, along with the presence of 10 caddisfly taxa in the sample, suggests that fine sediment deposition did not substantially compromise benthic substrate habitats. Overall taxa richness (37) was high, and 5 collected taxa were predators. Instream habitats were likely diverse and available. Reach-scale habitat features, such as streambank stability, riparian zone integrity, and natural channel morphology may have suffered some disturbance. Such disturbance may be reflected in the low stonefly taxa richness (2). No fewer than 8 semivoltine taxa were present at the site, implying that surface flow persisted year-round, and that life cycle-interrupting catastrophes did not recently occur. All expected functional components of an integrated benthic assemblage were present in the sample. The abundance of filter-feeders seemed to be entirely appropriate for this downstream site.

Fox Creek

Upstream of the USFS boundary, Fox Creek (FOX01) supported a sensitive and diverse benthic assemblage that appeared to be appropriate for a foothill stream. The biotic index value (3.06) was within expected limits, and the mayfly fauna was rich (8 taxa). Four cold-stenotherm taxa were among the sampled animals; these included the dipteran Glutops sp. and the stonefly *Doroneuria* sp.

Twenty "clinger" taxa and 6 caddisfly taxa are evidence that hard benthic substrates were not obliterated by fine sediment deposition. Other instream habitats appear to have been diverse, since the site supported at least 41 taxa and the predator fauna was rich (9 taxa). Stonefly taxa richness may be associated with reach-scale habitat features; in this case, streambank integrity, riparian zone function, and natural channel morphology were probably intact, since 6 stonefly taxa were collected. Dewatering or other disasters seem unlikely, since 9 semivoltine taxa were among the sampled assemblage. Gatherers dominated the functional mix; this suggests that ample fine particulate organic material was present here. All other expected functional components were also present in the sample.

Above the mouth of Andrus Creek, Fox Creek (FOX02) appeared to support a mildly tolerant assemblage; the biotic index value calculated for the sampled animals was 4.18. The calculation may have been skewed by the tolerance of the dominant taxon, which was the gregarious elmid *Optioservus* sp. Still, 8 mayfly taxa were present in the sample, suggesting that water quality was likely good at this site. Although 3 sensitive cold-stenotherm taxa were collected, none was abundant. There may have been a slight thermal challenge here. A few of the taxa supported at the site prefer warmer water temperatures, including the haliplid *Brychius* sp. and the planorbid snail Gyraulus sp.

Sediment deposition likely did not limit the accessibility of stony substrate habitats, since 21 "clinger" taxa were collected, and the site supported at least 10 caddisfly taxa. Other instream habitats were probably similarly undisturbed; the invertebrate fauna was exceptionally rich here. Forty-seven taxa were present in the sample. Of these, 11 taxa were predators. Stonefly taxa richness (4) was within expectations, suggesting that reach-scale habitat features were probably undisturbed. Abundant semivoltine animals (5 taxa) imply year-round surface flow and the absence of disastrous toxic inputs or scouring sediment pulses in the recent past. All expected functional components in apparently appropriate proportions were present.

Warmsprings Creek

Exceptionally high mayfly taxa richness (12) and low biotic index value (2.24) suggest that water quality was excellent at the upper site on Warmsprings Creek (WRMS01). No fewer than 6 cold-stenotherm taxa were supported at the site, including the sensitive mayflies *Baetis bicaudatus* and *Caudatella edmundsi*. Cold clean water appears to have characterized this site.

Nine caddisfly taxa and 31 "clinger" taxa were collected, suggesting that sediment deposition did not limit benthic habitats here. The high overall taxa richness (42) and high number of predator taxa (9) imply diverse and undisturbed instream habitats. Reach-scale habitat features may have been disturbed to some extent, since the stonefly taxa richness (3) was somewhat depressed. Since 8 semivoltine taxa were among the sampled animals, it seems unlikely that interruptions to long life cycles, such as site dewatering, toxic pollutants, or scouring sediments were among recent events here. The functional composition of the assemblage contained all expected elements. Abundant scrapers suggest the possibility that riparian shading of the channel was limited.

Excellent water quality appears to have persisted in Warmsprings Creek downstream to the lower site near Jackson (WRMS02). Mayfly richness (10) was high

here, and the biotic index value was low (2.73). Cold stenotherm taxa were rare at this site, however; only 2 individuals in a single taxon (*Cricotopus nostococladius*) were collected. A few individuals in taxa that prefer warm water were taken, including the caddisfly *Cheumatopsyche* sp. and the lymnaeid snail *Fossaria* sp. The caddisfly *Helicopsyche borealis* was especially abundant. Although it appears that water quality was good here, temperatures were apparently warmer than at the upper site.

Twenty-three "clinger" taxa and 9 caddisfly taxa were strong evidence for clean substrates, uncontaminated by sediment deposition. Diverse instream habitats were likely available, since the site supported at least 38 taxa, 8 of which were predators. Some disturbance to reach-scale habitat features such as riparian zone function or natural channel morphology may be evident in the low stonefly taxa richness; three taxa were collected. Abundant long-lived animals in 7 taxa were taken in the sample, implying that life-limiting catastrophes did not recently occur here. The functional mix was dominated by scrapers, which could indicate a lack of riparian shading. All other expected functional components were present.

Francis Creek

Water quality impairment is suggested by the high biotic index value (7.85) calculated for the benthic assemblage sampled at the upper site on Francis Creek (FRAN01). Low mayfly taxa richness (4) gives strength to this hypothesis. Warm water temperatures and/or nutrient enrichment are implied by these findings. The dominant taxon was the tolerant amphipod *Hyalella* sp.; not a single cold stenotherm was collected. It appears that lentic habitats were included with flowing water in the sampled area, since some of the taxa collected typically occur in non-flowing environs. For example, the dytiscids *Hygrotus* sp. and *Liodessus* sp. are associated with warm, still waters. *Liodessus* sp. is typically found in densely vegetated areas; either macrophytes or filamentous algae are suggested by its presence in the sample.

"Clingers" were rare in the sample; only 2 taxa were represented, and neither was abundant. These 2 taxa, *Simulium* sp. and Cricotopus (Cricotopus) spp. may have been associated with macrophyte surfaces. Not a single caddisfly was collected. These findings suggest that benthic habitats were mostly limited to soft sediments. Some sampled areas may have been hypoxic, since hemoglobin-bearing taxa, especially immature tubificid worms, made up 26% of sampled animals. Periodic dewatering cannot be ruled out here, since the few semivoltine taxa (4) that were collected are opportunistic colonizers. No stoneflies were taken in the sample; warm water temperatures may limit the accessibility of this site to this group. The functional composition of the fauna was dominated by gatherers, suggesting that fine particulate organic material was ample here.

Warm water temperatures and nutrient enrichment persist in Francis Creek at the downstream site near Stanley Creek (FRAN02). Warm-water forms dominate the assemblage collected here; among these were the mayfly *Tricorythodes* sp. and the amphipod *Hyalella* sp. A few heptageniid mayflies (*Nixe* sp.) provide evidence that some flowing areas were sampled, however, most of the taxa in the sample prefer lentic environs. The high biotic index value (6.06), low mayfly taxa richness (3), and high proportion of tolerant animals strongly suggest that nutrient enrichment influenced benthic community composition here.

Two caddisfly taxa and 9 "clinger" taxa were among the sampled animals. Among the "clingers" present here, many may be associated with macrophyte surfaces instead of benthic substrates. These findings indicate that substrates were likely predominantly silty or muddy. Periodic dewatering may additionally limit biotic health at this site. The dominance of gatherers among the functional components suggests that fine particulate organic material was the major energy source for this asssemblage.

Swamp Creek

High biotic index value (7.37) and low mayfly taxa richness (4) imply that nutrient enrichment and warm water temperatures characterized the site on Swamp Creek upstream of Highway 43 (SWAMP01). Thirty-eight percent of organisms taken in the sample, including the dominant animal *Paratendipes* sp. were hemoglobin-bearers, suggesting that sediments were likely hypoxic here. Near-lentic conditions and abundant macrophytes are suggested by the presence of *Anabolia* sp. and the mayfly *Caenis* sp.

Muddy or silty substrates were likely at this site, since both "clingers" and caddisflies associated with stony benthic substrates were rare. The functional skew toward gatherers suggests that fine particulate organic material was readily available. The considerable contribution of shredders to the mix was probably associated with macrophyte detritus rather than riparian inputs.

Farther downstream, Swamp Creek (SWAMP02) appears to develop greater gradient and stonier substrates. This site supported many lotic taxa; many lentic taxa were also present. Low gradient, still water areas apparently made up a large part of the sampled site. Among the caddisfly taxa present in the sample, several are characteristic of lentic environs, including *Anabolia* sp., *Mystacides* sp., and *Triaenodes* sp. The biotic index value (6.30) was elevated compared to expectations for a valley stream, and although the mayfly taxa richness (7) was high, several of these taxa are tolerant of warm water and nutrient enrichment. Among these are *Caenis* sp. and *Tricorythodes* sp.

Sediment deposition may have compromised benthic habitats to some extent, since the number of "clinger" taxa (13) taken in the sample was slightly lower than expected. The hemoglobin-bearing tubificid *Limnodrilus* sp. was abundant, suggesting that sediments were hypoxic in some sampled areas. Similar to the sites where near-lentic conditions constituted part of the sampled environment, gatherers dominated the functional mix.

North Fork Big Hole River

At the Big Hole Battlefield National Monument, the North Fork Big Hole River (BGHNF01) supported a benthic assemblage characteristic of relatively unimpaired riverine conditions in the MVFP Ecoregion. The biotic index value (4.11) was slightly elevated compared to expectations for lower-order streams, but seems entirely appropriate for a larger river. At least 12 mayfly taxa were present at the site; among these were the relatively sensitive *Epeorus albertae* and *Drunella spinifera*. Although not abundant, cold stenotherms were represented by 2 taxa.

Twenty-two "clinger" taxa and 7 caddisfly taxa were collected, suggesting that sediment deposition did not obliterate stony benthic substrate habitats. At least 42 taxa were supported at this site; instream habitats of all types were likely undisturbed and available. Some disturbance of reach-scale habitat features, such as riparian zone function or streambank stability may be indicated by the low stonefly taxa richness (3). Long-lived taxa were well-represented (6) which makes it seem unlikely that the North Fork suffered episodic dewatering or other catastrophes recently. All expected elements were present in the functional mix; although the proportion of filter-feeders was higher than expected for a low-order stream, the contribution of this group at this riverine site appears to be appropriate.

Good water quality appears to have persisted in the North Fork downstream. At the Lower North Fork Road (BGHNF02), the biotic index value (4.06) was suitable for riverine environs. Twelve mayfly taxa were present in the sampled assemblage, and 2 sensitive taxa were collected.

Sediment deposition probably did not totally obliterate stony substrate habitats here, since the site supported at least 19 "clinger" taxa. Caddisfly taxa were not as well-

represented as expected, however, and 4 sediment tolerant taxa were present in the sample. There is some evidence that macrophytes contributed to habitat complexity here, since the caddisfly *Triaenodes* sp. was collected. Instream habitats were likely diverse, since 38 taxa were taken. Reach-scale habitat features may have been disturbed to some extent. Low stonefly taxa richness (2) may be related to streambank instability, loss of riparian zone integrity, or disruption of natural channel morphology. Long-lived taxa richness (3) was low, and elmid beetles were the sole constituents of this group. Periodic dewatering or other limitations to long life-cycles cannot be ruled out here. The functional composition of the assemblage contained all expected elements. Similar to the upstream site, the proportional contribution of filter-feeders seemed entirely appropriate for a riverine environment.

McVey Creek

The upper site on McVey Creek (MCVY01) yielded a sample with only 22 organisms, in spite of the effort documented in field notes. Extremely low abundance of animals in kicknet samples when adequate sampling effort has been applied suggests impaired habitat or water quality conditions, and renders bioassessment unreliable. The sparse assemblage collected here cannot support interpretation.

Upstream of Highway 43, McVey Creek (MCVY02) is faunally similar to the other valley-floor sites sampled for this study, such as those on Francis Creek and Swamp Creek. Amphipods, leeches, and other non-insect taxa are important components of these assemblages, and high biotic index values are characteristic. In this case, the biotic index value was 6.28, indicating a tolerant assemblage. Four mayfly taxa were collected. These findings suggest nutrient enrichment and warm water temperatures.

"Clingers" were represented by 11 taxa, and 4 caddisfly taxa were present in the sample. Deposited fine sediments apparently compromised stony substrates here to some extent. Macrophytes may have contributed to overall habitat complexity, since the beetle *Haliplus* sp. and the damselfly *Argia* sp. were collected. Long-lived taxa were poorly represented; four individuals in 4 taxa were taken. This site may not support animals with long life-cycles because of periodic dewatering, thermal challenges, or toxic inputs. The functional composition of the assemblage is skewed toward gatherers, which appears to be typical of the valley floor sites sampled for this study.

Doolittle Creek

Doolittle Creek at the gauge station (DOLT01) supported a benthic assemblage characteristic of an unimpaired stream. The low biotic index value (2.73) and high mayfly taxa richness (9) indicate that water quality was likely excellent at this site. At least 11 cold stenotherm taxa and 13 sensitive taxa were present here. The sensitive taxa included the mayflies *Caudatella edmundsi* and *Baetis bicaudatus*, and the stonefly *Kogotus nonus*. Cold clean water appears to have been the rule here.

Twenty-two "clinger" taxa and 9 caddisfly taxa were among the collected animals, suggesting that stony substrates were not excessively contaminated by sediment deposition. Other instream habitats were likely undisturbed, since 40 taxa were counted in the sample. The stonefly fauna included 6 taxa; high stonefly taxa richness may be associated with intact reach-scale habitat features. Six semivoltine taxa were taken. Year-round surface flow is implied, and the absence of disastrous life-cycle interruptions such as scouring sediment pulses or toxic inputs seems likely. All expected functional components were present in the sample in appropriate proportions.

The sample collected at the site upstream of Highway 43 (DOLT02) yielded only 64 organisms; this is too few for reliable bioassessment. Field notes suggest a lengthy sampling effort, which could imply disturbances to water quality and/or habitat conditions severe enough to limit colonization by invertebrates.

Sawlog Creek

Although field information indicates that a lengthy sampling effort was made, the collection at Sawlog Creek (SWLG01) yielded only 20 organisms. Severe disruptions of habitat features or degradation of water quality could be suggested by this dearth of animals. Bioassessment or interpretation of the data is precluded by the small sample size.

Fishtrap Creek

At the upper site, Fishtrap Creek (FSHT01) supported a benthic assemblage that produced a biotic index value (2.93) indicating that water quality was probably good here. Nine mayfly taxa were collected in the sample; this finding supports the hypothesis.

Twenty "clinger" taxa and 8 caddisfly taxa were present, suggesting that stony substrate habitats were not rendered unusable by sediment deposition. Taxa richness (41) and predator taxa richness (9) were high, thus it seems likely that diverse habitats were available at this site. Stoneflies were represented by only 3 taxa; this is somewhat fewer than expected, and could be related to disturbance to streambank stability, riparian zone function, or other reach-scale habitat features. Eight long-lived taxa were collected, suggesting that surface flow persisted here year-round, and that catastrophic interruptions of long life cycles had not recently occurred. The functional composition of the assemblage contained all expected constituents. The dominance of gatherers in the functional mix may be associated with ample supplies of fine particulate organic material.

Downstream from the Highway 43 bridge, Fishtrap Creek (FSHT02) appeared to support more taxa than at the upstream site. Nine mayfly taxa were collected, and the biotic index value calculated for the assemblage as a whole was 3.96, which seems to be entirely appropriate for a valley floor stream site.

"Clinger" taxa (22) and caddisfly taxa (10) were well-represented, likely indicating that sediment deposition was not limiting to biotic health here. No fewer than 6 stonefly taxa were supported at the site; high stonefly taxa richness may be associated with undisturbed reach-scale habitat features. Long life cycles were probably not interrupted by dewatering or other catastrophes, since 8 semivoltine taxa were collected. The functional mix was made up of all expected components. The dominance of gatherers suggests that fine organic particulate material was a major energy source for this assemblage.

LaMarche Creek

Upstream of the USFS boundary, LaMarche Creek (LMCH01) supported a benthic assemblage characteristic of minimally disturbed streams in the MVFP Ecoregion. The low biotic index value (2.14) and high mayfly taxa richness (11) suggest that water quality was excellent at this site. Three sensitive cold stenotherm taxa were collected, including the mayflies *Caudatella edmundsi* and *Drunella doddsi*. Cold clean water apparently characterized this reach.

Eight caddisfly taxa and 23 "clinger" taxa were taken; it seems unlikely that benthic habitats were compromised by sediment deposition here. At least 42 distinct taxa were supported at this site, and 13 of these were predators. Instream habitats of diverse types were apparently available and undisturbed. Reach-scale habitat features were likely intact, since stonefly taxa richness (5) was high. Semivoltine taxa included the perlid stonefly *Hesperoperla pacifica*, as well as 3 other taxa. The presence of these taxa suggests that dewatering or other disasters did not recently occur in this reach. The functional composition of the assemblage contained all expected elements in appropriate proportions.

Good water quality and intact habitats appear to have persisted to the downstream site on LaMarche Creek (LMCH02), where 12 mayfly taxa were collected. The biotic index value (3.21) was within expectations for a valley stream.

Sediment deposition was probably not a limiting factor at this site, since 22 "clinger" taxa and 9 caddisfly taxa were collected here. The fauna represented in this sample was among the richest collected in this study; forty-nine taxa were identified. Instream habitats were likely plentiful and diverse. Reach-scale habitat features may have suffered some disturbance, since stonefly taxa richness (3) was somewhat lower than expected. Such disturbance could take the form of unstable streambanks, loss of riparian zone function, or altered channel morphology. Long-lived taxa were well-represented in the sample collected at this site. Among the 5 semivoltine taxa taken here were the caddisflies *Arctopsyche grandis* and *Brachycentrus americanus*. These findings suggest that surface flow persisted year-round here. The functional mix was appropriately proportioned among the expected components. Gatherers dominated the mix, implying an ample supply of fine particulate organic matter.

Elkhorn Creek

Although field notes indicate that sampling effort was lengthy, samples collected at both Elkhorn Creek sites did not contain enough invertebrates to meet bioassessment requirements. While scores are unreliable, limited observations about the sampled assemblages can be noted. At the upper site, located downstream of the Coolidge town site (ELKH01) the presence of 5 sensitive cold stenotherm taxa in the scant sample suggest that water quality was good at this site. Above the mouth of Jackson Creek (ELKH02), 7 such taxa were collected, indicating that excellent water quality persisted to this downstream site. The presence of the chloroperlid stonefly *Paraperla* sp. at this site may be an indication of clean substrates free from sediment deposition, since this animal is oriented toward hyporheic environs. Six semivoltine taxa were collected at the lower site, making it seem unlikely that recent dewatering or other limiting catastrophes occurred here. A single blephariceri d pupa was taken in the sample, suggesting that boulders and rapid flow conditions may have accounted for the small sample size.

Gold Creek

Both sampled sites on Gold Creek supported invertebrate assemblages characteristic of unimpaired montane streams. Low biotic index values (1.78 at the upper site and 1.57 at the lower site) indicate excellent water quality in the sampled reaches. Eleven cold stenotherm taxa were collected at the upper site (GOLD01) and 8 were taken at the lower site (GOLD02). Cold clean water apparently characterized Gold Creek.

Fourteen "clinger" taxa and 8 caddisfly taxa were collected at the upper site, while the lower site supported no fewer than 15 "clinger" taxa and 8 caddisfly taxa. Sediment deposition apparently did not limit benthic habitats at either location. Taxa richness was high at both sites (31 at the lower site, 33 at the upper site), and many predator taxa were taken in each sample. Instream habitats were likely diverse and abundantly available. While stonefly taxa richness (5) was high at the lower site, only 2 stonefly taxa were taken in the sample collected at the upper site. Disruption of reach-scale habitat features such as riparian zone integrity may account for this. Long-lived taxa were well-represented at the lower site, but only 2 such taxa were collected at the upper site. Periodic dewatering cannot be ruled out at the upper site. Functionally, the assemblages collected at the two sites were similar. Both lacked the expected proportional contribution of shredders, which suggests that riparian inputs of large organic material may have been lacking, or perhaps hydrologic conditions in Gold Creek did not favor retention of such material.

Delano Creek

Upstream of the culvert on Forest Road 83, Delano Creek (DLNO01) supported a diverse, sensitive, and functional assemblage typical of unimpaired montane streams. The biotic index value (2.32) and mayfly taxa richness (11) both indicated excellent water quality conditions. No fewer than 13 cold stenotherm taxa were present at the site, including the mayfly *Drunella doddsi* and the stonefly *Yoraperla brevis.*

The 19 "clinger" taxa and 10 caddisfly taxa taken in the sample strongly suggest that sediment deposition did not limit the availability of stony substrate habitats. Seventeen predator taxa were among the 44 total taxa identified at the site; instream habitats of diverse types appear to have been undisturbed. Nine stonefly taxa were present in the sample. High stonefly taxa richness may indicate intact reach scale habitat features, such as stable streambanks, functional riparian zones, and natural channel morphology. Dewatering or other interruptions to long life cycles are unlikely to have been recent occurrences here, since 6 semivoltine taxa were among the collected animals. The functional composition of the benthic assemblage included all expected elements in apparently appropriate proportions.

The invertebrates collected at the lower site on Delano Creek (DLNO02) were generally somewhat more tolerant; the biotic index value calculated for this assemblage was 3.12. Eight mayfly taxa were present in the sample. These findings suggest that water quality was good at this site. Five cold stenotherms taken in the collection included the stoneflies *Visoka cataractae* and *Megarcys* sp. Cold clean water appears to have characterized this site.

Both the "clinger" and caddisfly faunae were depauperate, however. Only 9 "clinger" taxa were present in the sample, and only 2 caddisfly taxa were collected. These findings suggest that sediment deposition may have limited stony benthic habitats at this site. Stonefly taxa were also less rich than expected; low Plecoptera taxa richness may be associated with disruption of reach scale habitat features. The dearth of shredder taxa among the functional components suggests that riparian zone function may have been limited here. Long-lived taxa were conspicuously scarce; only 2 semivoltine taxa were present in the collection. Midges made up 48% of sampled animals. These findings could be related to periodic dewatering of the reach, recent scouring sediment pulses, or other catastrophic interruptions of long life cycles.

Jerry Creek

Water quality indicators calculated on the assemblage collected at Jerry Creek (JERR01) suggest that water quality was good at this site. The biotic index value (2.19) was low, and the mayfly taxa richness (9) was high. Three cold stenotherm taxa were present at the site, including the mayflies *Baetis bicaudatus* and *Drunella spinifera.* These findings indicate the probability that cold clean water characterized this site.

Fewer "clinger" taxa than expected were taken in the sample, and only 2 caddisfly taxa were identified. Sediment deposition may have compromised stony substrate habitats here. Reach scale habitat features may have been disturbed to some extent, since the stonefly taxa richness was low; only 2 Plecoptera taxa were collected. Low stonefly richness may be associated with unstable streambanks, channel alteration, or loss of riparian zone integrity. A single individual in a long-lived taxon was present in the sample. Long-lived taxa are expected to be common in streams where surface flow persists year-round, and where other catastrophes such as scouring sediment pulses have not recently occurred. All expected functional elements were present in the sample. The small number of filter-feeders was notable, suggesting that fine suspended particulate material was sparse.

Charcoal Gulch Creek

The sample collected at Charcoal Gulch Creek (CHRG01) consisted of 181 organisms, which is fewer than necessary to render the bioassessment method reliable. In spite of this, some observations relative to water and habitat quality can be ventured. Five sensitive cold stenotherm taxa were among the sampled animals, suggesting that cold clean water probably characterized the site. Turbellarian flatworms were common; groundwater inputs may influence flows here.

The site supported at least 6 caddisfly taxa, but only 10 "clingers" were taken. Nonetheless, it seems unlikely that sediment deposition was a significant limitation to benthic colonization. Although the sample size was small, 37 taxa were identified, suggesting that instream habitats were diverse and undisturbed. Reach scale habitat features were probably undisturbed as well, since stonefly taxa richness (4) was within expected limits. Filter-feeders were rare in the sample; all other expected functional components were present.

Divide Creek

Non-insect taxa, especially snails and worms, dominated the sample collected at the Divide Creek site at Freely (DIVD01). Only 3 individuals in the mayfly genus *Tricorythodes* sp. were taken in the sample, and the biotic index value (7.24) was high. Water quality was likely impaired by warm temperatures and nutrient enrichment here. No cold stenotherms were among the sampled assemblage. Near-lentic conditions were at least part of the sampled environs.

The number of "clinger" taxa (4) collected was very low, and a single caddisfly taxon was present in the sample. Silty or muddy substrates were likely. Only 23 taxa were identified, suggesting that instream habitats were monotonous; it seems probable that macrophyte surfaces and the water column provided the most hospitable habitats at this site. Immature corixids were abundant. Stoneflies were likely excluded by warm temperatures, and lack of suitable flow conditions. Dewatering or lethal thermal challenges cannot be ruled out at this site; although 4 semivoltine taxa were collected, 2 of these are opportunistic colonizers (*Haliplus* sp. and *Brychius* sp.), and no adults were apparent among the elmids. The functional composition of the assemblage indicates that macrophytes provide an important energy source for the invertebrate community.

A moderately rich mayfly fauna (4 taxa) and lower biotic index value (3.78) suggest that the downstream site on Divide Creek (DIVD02) had somewhat better water quality compared to the upstream site. The composition of the invertebrate assemblage seemed to indicate that both flowing and still water areas were sampled here. The heptageniid mayfly *Nixe* sp. was present; this animal requires lotic environs, but the dytiscid *Liodessus* sp. suggests dense vegetation and lentic flow conditions. Warm water temperatures and nutrient enrichment are indicated by the taxa present here.

Silty or muddy benthic substrates likely dominate the site, since caddisfly taxa (1) were rare and "clingers" uncommon (5). Most of the "clinger" taxa collected in the sample were probably associated with macrophyte surfaces rather than stony surfaces. No stoneflies were collected; thermal conditions do not seem to have been favorable for them. Dewatering or periodic lethal temperatures cannot be ruled out, since non-opportunistic semivoltine animals were apparently not common here. Gatherers dominated the functional composition of the invertebrate assemblage, suggesting an ample supply of fine particulate organic material.

MacLean Creek

Although the mayfly taxa richness (4) of the sample collected at MacLean Creek (MCLN01) was lower than expected, the biotic index value (3.27) suggests that water quality was essentially unimpaired here. The site supported at least 7 sensitive cold

stenotherm taxa, including the stonefly *Zapada columbiana* and the caddisfly *Cryptochia* sp. These findings imply that cold clean water characterized this site. The presence of abundant turbellarian flatworms in the sampled assemblage suggests that groundwater may influence flow here.

Only 7 "clinger" taxa were collected, but caddisfly taxa richness (5) was within expectations. Sediment deposition may compromise hard substrate habitats to some extent at this site. High overall taxa richness (36) and abundant predator taxa (11) make it seem likely that instream habitats of diverse types were available. Six stonefly taxa were present in the sample; this finding corresponds to expectations for a foothill watershed in which riparian zone function, stream channel morphology, and streambank integrity are all intact. A few semivoltine taxa were collected. Periodic dewatering or other life-interrupting catastrophes cannot be ruled out. The functional composition of the invertebrate assemblage incorporated all expected elements. Abundant shredders suggest ample inputs of organic debris from the riparian zone and hydrologic conditions that promote retention of such material. The dearth of filter-feeders is notable, and suggests that suspended fine organic matter was not an important energy source for this assemblage.

Soap Creek

At the upper site on Soap Creek (SOAP01), low mayfly taxa richness (4) coupled with a relatively high biotic index value (5.56) suggest that water quality was impaired. The dominant taxon, a fingernail clam in the family Pisidiidae, is quite tolerant and skews the biotic index value. Other components of the invertebrate fauna include 2 sensitive cold stenotherm taxa (the caddisfly *Apatania* sp. and the dipteran *Glutops* sp.). Although not abundant, the presence of these 2 animals suggests that impairment to water quality was probably not as severe as the biotic index value implies. Mild nutrient enrichment is the likely source of impairment. Abundant turbellarian flatworms suggest that groundwater may influence flow here.

Only 9 "clinger" taxa were taken in the sample. Five caddisfly taxa were present, but all were uncommon. Sediment deposition appears to have compromised stony substrate habitats at this site. Low stonefly taxa richness (2) suggests that reach scale habitat features may have suffered disturbance. Only 7 individual stoneflies were present. Periodic dewatering cannot be ruled out, since the sample contained representatives of only 2 semivoltine taxa. Both taxa were beetles in the family Elmidae (*Heterlimnius* sp. and *Optioservus* sp.) and adults among them were rare. The functional composition of the assemblage was skewed toward gatherers, a reflection of the dominance of fingernail clams at the site.

Better water quality was suggested by the invertebrate assemblage collected at the lower Soap Creek site (SOAP02). Here 5 mayfly taxa were taken in the sample, and the biotic index calculated for the assemblage as a whole was 4.30. Fingernail clams made up 14% of the sampled assemblage, and the biotic index value continued to show their influence on the calculation. There may have been some mild nutrient enrichment at this site. Three cold stenotherm taxa were collected, suggesting that water temperatures were cold. Abundant turbellarian flatworms suggested that groundwater influenced flow here.

The "clinger" fauna (12 taxa) was richer here than at the lower site, but remained less diverse than expected. Caddisfly taxa richness (4) was also low. Sediment deposition may have contaminated stony substrates to some extent. Overall taxa richness (38), however, was high; this suggests that instream habitats were not extensively disturbed. Only 3 stonefly taxa were taken in the sample; low stonefly richness may be associated with disturbance to reach scale habitat features. Long-lived taxa (6) were well-represented, thus it seems unlikely that recent dewatering or other disasters influenced biotic health here. Filter-feeders were notably absent from the functional mix, which was dominated by gatherers.

Camp Creek

Upstream from its confluence with Wickup Creek, Camp Creek (CAMP03) supports a sensitive, diverse, and functional invertebrate assemblage characteristic of unimpaired montane streams in the region. The low biotic index value (2.41) and high mayfly taxa richness (11) suggest excellent water quality. The sample included representatives of 4 cold stenotherm taxa, including the stonefly *Doroneuria* sp. and the mayfly *Drunella doddsi.* Cold clean water is indicated by these findings.

At least 20 "clinger" taxa and 8 caddisfly taxa were supported at this site, implying that stony benthic substrates were essentially free from sediment deposition. Total taxa richness (41) was high; instream habitats were likely diverse and available. Five stonefly taxa were collected, suggesting that reach scale habitat features were undisturbed. Dewatering or other life cycle interruptions seem unlikely since at least 8 semivoltine taxa were present at the site. Functionally, all expected constituents were appropriately represented. The gregarious elmid *Heterlimnius* sp. dominated the taxonomic composition of the sampled assemblage.

Two miles east of the Interstate highway, Camp Creek (CAMP02) exhibits degraded water quality and habitat disturbances. A single taxon, the tolerant *Baetis tricaudatus,* represented the mayfly fauna here. The biotic index value (4.19) was higher than expected for a valley stream. Impairment by mild nutrient enrichment seems the likely explanation for these findings. The caddisfly *Hydroptila* sp. was common, suggesting that filamentous algae were present at the site.

Only 9 "clinger" taxa and 3 caddisfly taxa were collected, suggesting that sediment deposition may have limited the availability of stony substrate habitats at this site. The overall taxa richness (30) was also somewhat blunted; instream habitats may have been monotonous. Reach scale habitat features such as streambanks, riparian zones, and channel morphological components were probably generally intact, since the stonefly taxa richness (5) was within expectations. Although only 3 semivoltine taxa were present, adult elmids were common; it seems probable that dewatering or other catastrophes had not recently affected this reach. The absence of filter-feeders from the functional mix was notable. All other functional components were present.

Near its mouth, Camp Creek (CAMP01) yielded a sample with few mayfly taxa (3) and a substantially elevated biotic index value (6.96). Worms, scuds, and biting midges (Ceratopogoninae) dominated the fauna collected here. Nutrient enrichment is suggested by the taxonomic composition of the sampled assemblage. No cold stenotherms were present in the sample; warm water temperatures may have additionally limited biotic potential here.

A single caddisfly was identified, and "clinger" taxa richness (7) was low. Silty or muddy substrates were likely. Near-lentic flow conditions are suggested by the lack of rheophilic taxa. Stoneflies may have been excluded by water quality conditions or unsuitable flow regimes. All 3 semivoltine taxa collected here were represented only by larval forms; episodic dewatering or lethal thermal challenges cannot be ruled out. The functional mix was dominated by gatherers, consistent with nutrient enriched environs.

Grose Creek

The high biotic index value (4.28) and low mayfly taxa richness (1) make it seem likely that water quality at the sampled site on Grose Creek (GROS01) was impaired by nutrient enrichment and warm water temperatures. No sensitive taxa and no cold stenotherms were present in the sample. Groundwater may influence flow at this site; turbellarian flatworms were common.

Only 4 caddisfly taxa and 7 "clinger" taxa were collected. Sediment deposition may interfere with the availability of stony substrate habitats. Stoneflies were represented by a single taxon (*Malenka* sp.); other taxa may have been excluded by

water quality limitations. Adults were present among the collected elmid beetles, and other semivoltine taxa were also present, suggesting that dewatering or other recent disasters were unlikely. The functional composition of the assemblage was made up of all the expected elements; predators were abundant.

Lost Creek

Good water quality apparently characterized the upstream site on Lost Creek (LOST02), although only 4 mayfly taxa were present in the invertebrate sample. The low biotic index value (3.08) lends credibility to this hypothesis. No fewer than 8 cold stenotherm taxa were collected here, including the mayflies *Baetis bicaudatus* and *Epeorus grandis*. Turbellarian flatworms were prolific; these animals may be associated with areas of groundwater input.

Twelve "clinger" taxa are slightly fewer than expected, but 9 caddisfly taxa were present in the sample. It seems unlikely that sediment deposition appreciably limited access to hard substrate habitats. Overall taxa richness (37) was high; diverse undisturbed instream habitats appear to be indicated. The rich stonefly fauna (7 taxa) may be associated with intact reach scale habitat features such as streambanks, riparian zones, and channel morphology. Semivoltine taxa were adequately represented; recent dewatering, scour by sediment pulses, or other lethal catastrophes probably did not occur here. Filter-feeders were notably lacking, consistent with a low order stream. All other expected functional components were present in appropriate proportions.

One mile west of the freeway, good water quality persisted in Lost Creek (LOST01). Six mayfly taxa were present in the sample, and the biotic index value (3.08) was within expected limits for a foothill stream. Among the sampled animals were 3 cold stenotherm taxa. Water temperatures appear to have been appropriate for this stream. The large number of turbellarian flatworms in the collection suggests that groundwater inputs contributed to flow in this reach.

Seven caddisfly taxa were collected, along with 13 "clinger" taxa. Although the "clinger" fauna was slightly less rich than expected, sediment deposition probably did not obliterate stony benthic substrates. The high taxa richness (42) suggests that instream habitats were generally undisturbed. Abundant stoneflies in 6 taxa were present in the sample; reach scale habitat features were probably intact. Dewatering or other catastrophic insults apparently did not recently occur here, since the site supported at least 6 semivoltine taxa. Functionally, the very small contribution of filter-feeders was notable. All other expected elements were appropriately represented.

CONCLUSIONS

- Both sites on Pine Creek supported assemblages that exhibited symptoms of tolerance to warmer water temperatures. The thermal regimes of Pine Creek at these locations may be entirely appropriate for a valley stream. Reach-scale habitat features may have suffered some disturbance at the lower site (PINE02).
- Benthic assemblages present in Fox Creek were diverse and sensitive in the upper reach (FOX01), and more tolerant to warmer water in the lower reach (FOX02).
- Warming water temperatures between the upstream reach (WRMS01) and the downstream reach (WRMS02) in Warmsprings Creek. At both sites, limited stonefly fauna and dominant scrapers suggested the possibility that riparian shading was limited.
- The sampled reaches of Francis Creek (FRAN01 and FRAN02) yielded invertebrate assemblages characteristic of low gradient, muddy or silty valley channels. Warm water temperatures, near-lentic flow conditions, and nutrient enrichment appear to be limiting factors at these sites.

- Swamp Creek assemblages suggest low gradient, silty channels, and near-lentic conditions. Warm water temperatures and nutrient enrichment likely limit biotic health at both sites (SWMP01 and SWMP02). The lower site apparently had both standing water and flowing water, and both habitat types appear to have been sampled.
- The North Fork Big Hole River supported benthic assemblages characteristic of relatively unimpaired riverine sites. Good water quality and adequate habitat features are consistent with the aquatic fauna collected at both sampled sites (BGHNF01 and BGHNF02).
- The upper site on McVey Creek (MCVY01) yielded a sample with too few organisms for reliable bioassessment. This dearth of benthic animals could indicate severe water quality or habitat disturbances. The lower site (MCVY02) was similar to the other valley floor sites sampled for this study: warm water temperatures and nutrient enrichment were likely.
- On Doolittle Creek, the upper site (DOLT01) supported an assemblage characteristic of an unimpaired montane stream. The lower site (DOLT02) yielded a sample with too few organisms for reliable bioassessment. Given adequate sampling effort, small sample size could suggest severe challenges to water quality and/or habitat.
- The sample collected at Sawlog Creek (SWLG01) contained too few organisms for bioassessment or interpretation. Small sample size when sampling effort has been adequate could suggest severe habitat disturbances or water quality problems.
- Good water quality and intact instream habitats seem to be indicated by the sampled assemblages at both sites on Fishtrap Creek (FSHT01 and FSHT02).
- LaMarche Creek supported diverse invertebrate assemblages at both sampled sites (LMCH01 and LMCH02). Good water quality and undisturbed instream habitats are suggested by characteristics of the sampled taxa.
- Boulders and rapid flow may have resulted in low invertebrate abundances in samples collected at sites on Elkhorn Creek (ELKH01 and ELKH02). Although bioassessment scores are unreliable due to scant sample sizes, characteristics of the assemblages suggest cold clean water at both sites, and substrates clean of sediment deposition at the lower site.
- Both sites on Gold Creek (GOLD01 and GOLD02) supported diverse, sensitive benthic assemblages characteristic of unimpaired montane streams. Excellent water quality and cold temperatures were suggested. Instream habitat indicators implied that there were abundant diverse niches.
- Delano Creek supported a functional, diverse, and sensitive assemblage in its upper reach (DLNO01), but sediment deposition appeared to limit the potential of the lower site (DLNO02). Dewatering or other disasters may have recently occurred at the lower site.
- Water quality was probably good at the Jerry Creek site (JERR01), but sediment deposition and reach scale habitat disturbances may limit biologic potential here. Recent dewatering, scouring sediment pulses, or other life cycle interruptions cannot be ruled out.
- In spite of the small sample collected at Charcoal Gulch Creek (CHRG01), the taxonomic composition of the assemblage seems to indicate good water quality and undisturbed habitats.
- Divide Creek sites (DIVD01 and DIVD02) had characteristics of low gradient valley floor sites; warm water temperatures, near-lentic flow conditions over large sampled areas, and nutrient enrichment may limit the invertebrate assemblages to tolerant taxa.

- The invertebrate assemblage collected at MacLean Creek (MCLN01) suggested cold clean water. Sediment deposition may impair benthic habitats here. Periodic dewatering cannot be ruled out.
- Sediment deposition and mild nutrient enrichment may have influenced the benthic assemblages at both Soap Creek sites (SOAP01 and SOAP02). Periodic dewatering cannot be ruled out at the upper site.
- Camp Creek appeared to be essentially unimpaired at the uppermost sampled site (CAMP03) but impairment by nutrient enrichment and fine sediments increased in downstream reaches (CAMP02 and CAMP01). Periodic dewatering or high water temperatures may further limit biotic potential in the middle and lower reaches.
- Water quality impairment by nutrients and warm temperatures may limit the invertebrate fauna at Grose Creek (GROS01). Sediment deposition appears to contaminate the substrates.
- Both sites on Lost Creek (LOST02 and LOST01) supported diverse, sensitive, functional assemblages characteristic of unimpaired streams.

Ordination Studies

To summarize similarities between invertebrate assemblages in this study, a sites-by-taxa matrix was constructed, using the relative abundance of each taxon at each site. Principal Components Analysis (PCA) was used to generate a graphical ordination of the data. Ordination produces a plot in which similar assemblages are graphed close together, and dissimilar assemblages are far apart. Figures 3 and 4 give the results of the PCA.

Figure 3 illustrates the ordination of all 40 invertebrate assemblages. Swamp Creek (SWMP01 and SWMP02) and Grose Creek (GROS01) assemblages are clearly outliers. Large proportions of the tolerant mayfly *Caenis* sp. distinguish the Swamp Creek communities. This creature is typically associated with lentic flow conditions, abundant macrophytes, and nutrient enrichment. Swamp Creek sites were the only sites harboring *Caenis* sp. Grose Creek yielded an assemblage unique among those sampled in that it was dominated by the predatory filter-feeding caddisfly *Parapsyche almota*. The unusual assemblage collected here contained lentic as well as lotic, and relatively sensitive as well as very tolerant elements.

The remaining assemblages occupy 2 tight clusters and an additional loose array in Figure 3. In order to magnify the similarities and differences in these non-outlying assemblages, the ordination was re-run, with the Swamp Creek and Grose Creek sites eliminated. The resulting ordination is given in Figure 4.

In this figure, the majority of invertebrate assemblages are clustered tightly in the center of the plot, suggesting that most assemblages studied had a high degree of similarity. These assemblages can be generally characterized by more sensitive taxa such as the stonefly *Kogotus* sp., heptageniid mayflies including *Cinygmula* sp., *Epeorus* spp., and ephemerellid mayflies such as *Serratella tibialis* and *Ephemerella* spp. These taxa suggest instream habitats with clean stony substrates, and good water quality.

The loose array of sites including Lost Creek (LOST01 and LOST02), the lower site on Delano Creek (DLNO02), Charcoal Gulch (CHRG01), and MacLean Creek (MCLN01) support sensitive assemblages similar to those of the large cluster, but are distinguished by the universal occurrence among them of moderate to large numbers of turbellarian flatworms. These are the only sites to support the leuctrid stonefly *Despaxia augusta*. These observations seem to suggest that groundwater inputs and hyporheic connections were perhaps more important at these sites than at others.

Figure 3. Ordination (PCA) of aquatic invertebrate assemblages collected at 40 sites in the Big Hole River watershed, 2003.

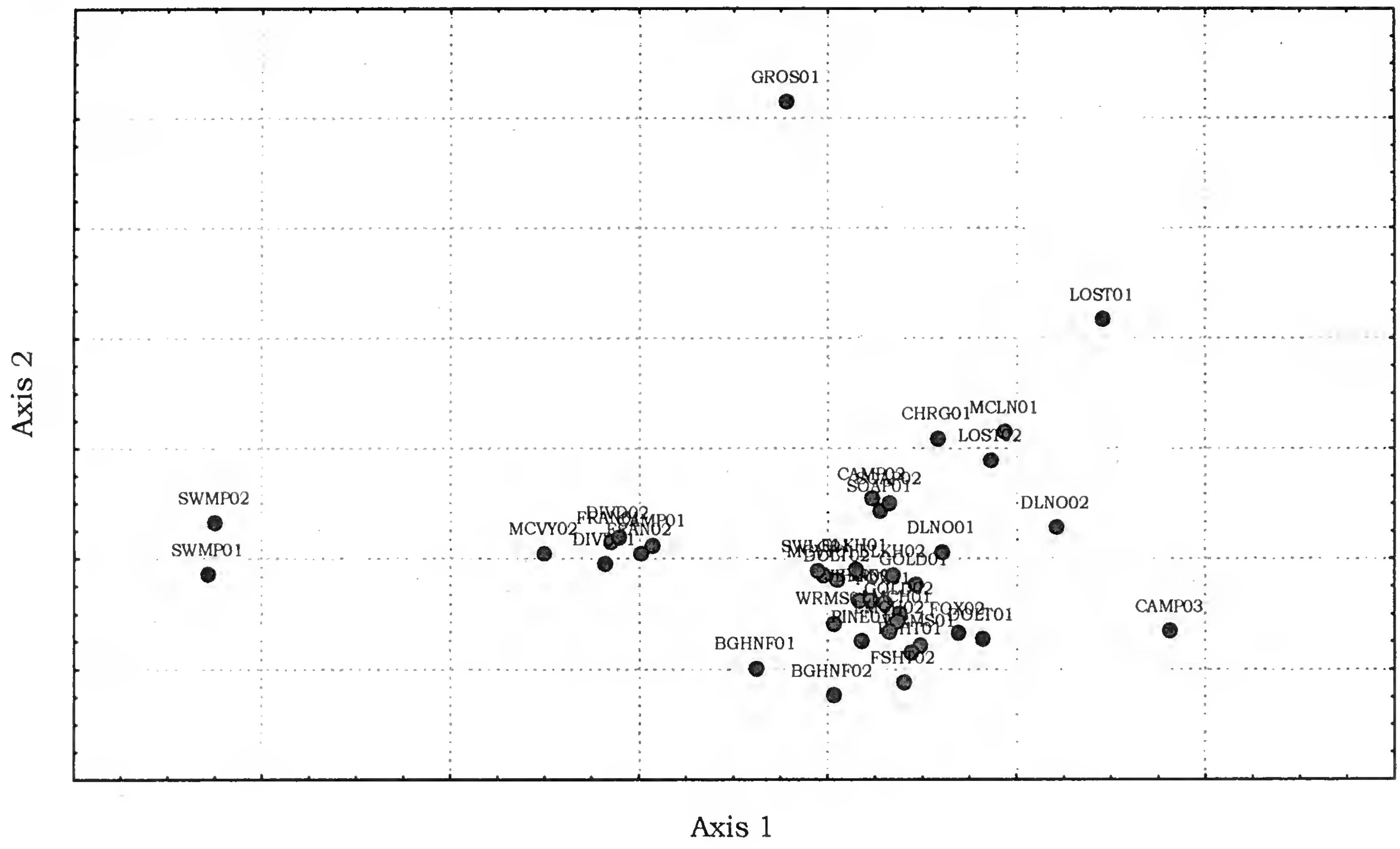
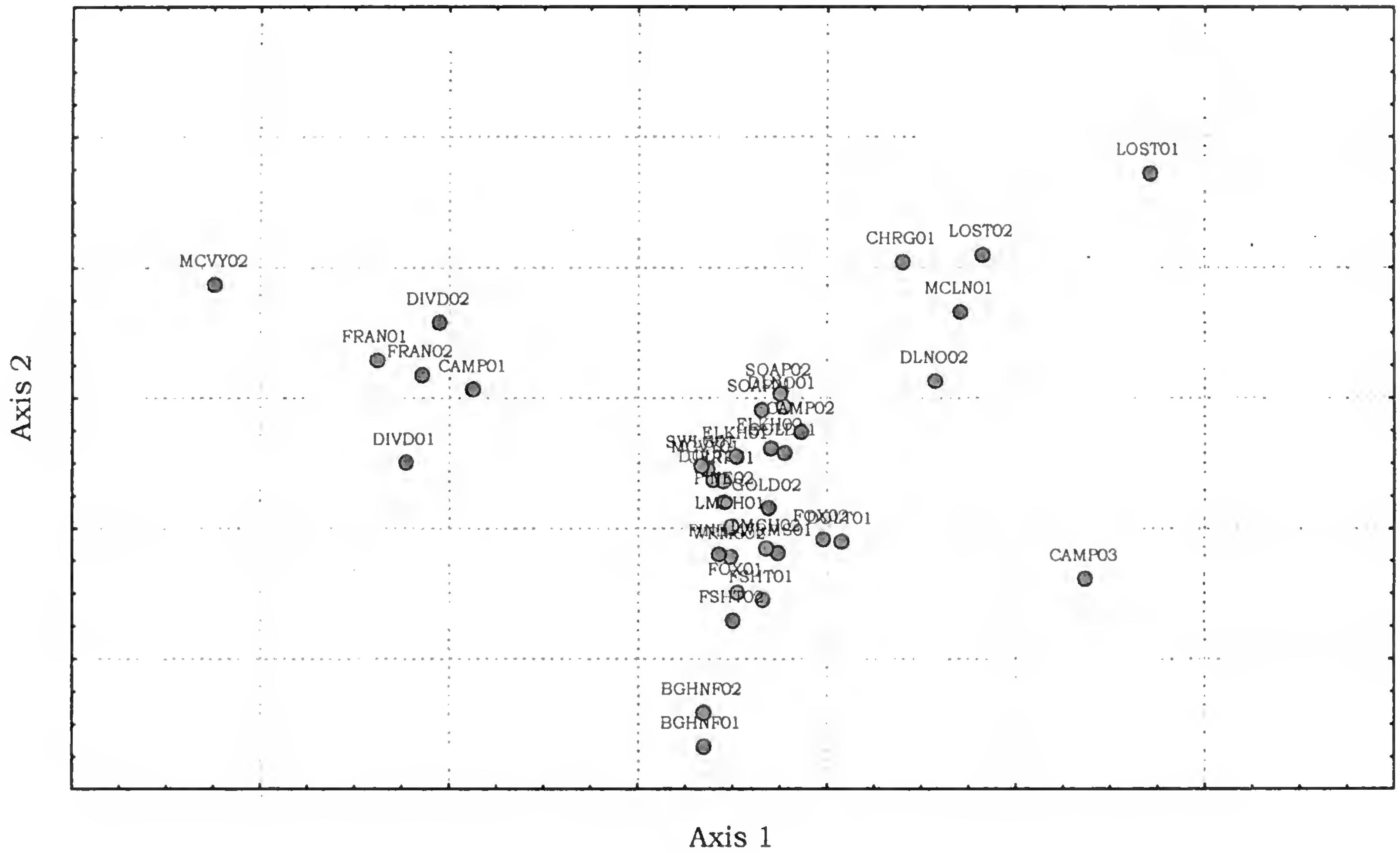


Figure 4. Ordination of aquatic invertebrate assemblages from 37 sites in the Big Hole River watershed, 2003. Outliers removed.



The 2 sampled sites on the North Fork Big Hole River (BGHNF01and BGHNF02) were distinguished from the other sites by assemblages containing forms such as *Brachycentrus occidentalis*, *Timpanoga hecuba*, and *Pteronarcella* sp. At the upper site on Camp Creek (CAMP03) which appears as an outlier in this plot, large numbers of both *Hydropsyche* sp. and *Arctopsyche grandis* were important components of the invertebrate assemblage. It was also the only site to support large numbers of the sensitive elmid *Lara avara*.

The cluster of sites including Divide Creek (DIVD01 and DIVD02), Francis Creek (FRAN01 and FRAN02), and the lowermost site on Camp Creek (CAMP01) are the low gradient, soft-bottomed sites that supported assemblages rich in amphipods (*Hyalella* sp.) leeches, and corixids.

Habitat Assessment

Figures 5a and 5b graphically compare total habitat assessment scores recorded for the 40 sites in this study. Tables 5a through 5d show the habitat parameters evaluated, parameter scores and overall habitat evaluations for the sites studied. Habitat conditions at all sites were judged either optimal or sub-optimal.

Figure 5a. Total habitat assessment scores for 21 sites in the Big Hole River watershed. 2003.

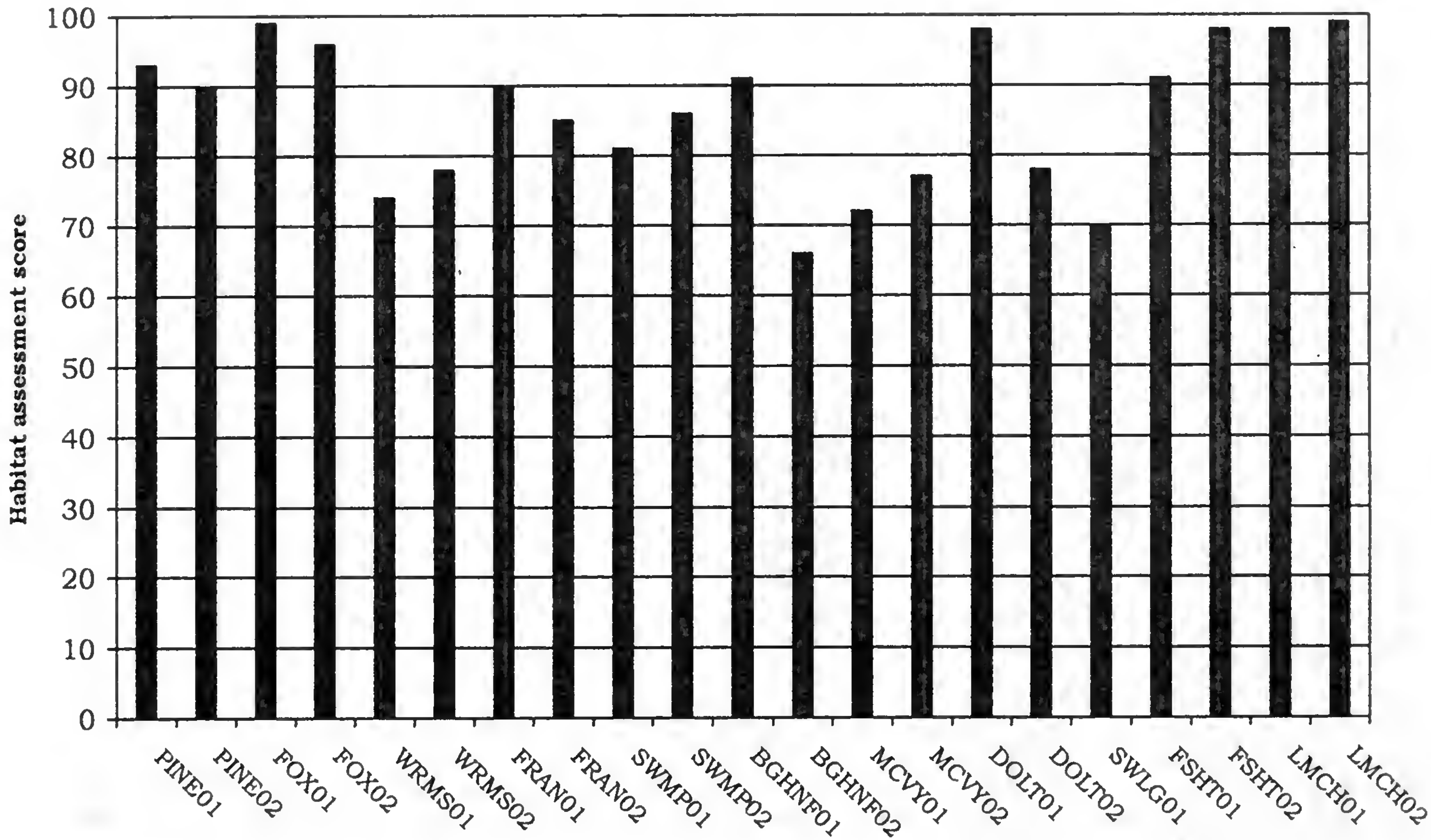


Figure 5b. Total habitat assessment scores for 19 sites in the Big Hole River watershed. 2003.

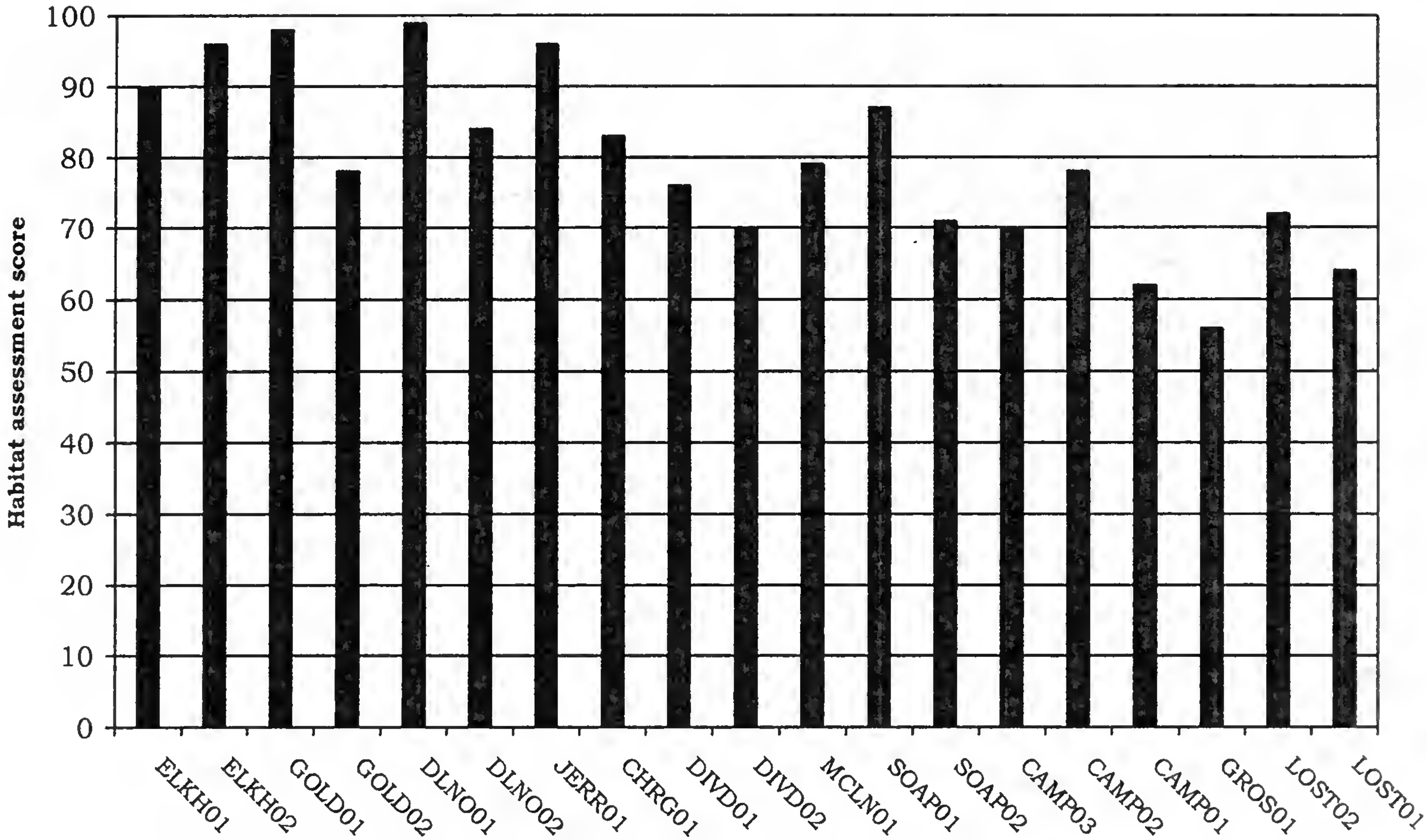


Table 5a. Stream and riparian habitat assessment. These sites were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence. Big Hole River watershed 2003.

Max. possible score	Parameter	PINE 01	FOX 01	WRMS 01	FRAN 02	DOLT 01	DOLT 02	SWLG 01	FHST 02	LMCH 02
10	Riffle development	10	10	10	8	10	10	7	10	10
10	Benthic substrate	10	10	10	8	10	8	4	10	10
20	Embeddedness	20	20	10	15	19	11	8	19	20
20	Channel alteration	20	20	10	20	20	20	15	20	20
20	Sediment deposition	19	20	10	18	19	15	16	18	19
20	Channel flow status	20	20	10	19	20	18	14	20	20
20	Bank stability	7/7	9/9	9/9	8/8	10/10	8/8	8/8	10/10	10/10
20	Bank vegetation	8/8	10/10	10/10	7/7	9/9	8/8	9/9	10/10	10/10
20	Vegetated zone	10/10	10/10	10/10	9/9	10/10	5/5	10/4	10/10	10/10
160	Total	149	158	118	136	156	124	112	157	159
	Percent of maximum CONDITION*	**93%** Optimal	**99%** Optimal	**74%** Sub-optimal	**85%** Optimal	**98%** Optimal	**78%** Sub-optimal	**70%** Sub-optimal	**98%** Optimal	**99%** Optimal

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

Table 5b. Stream and riparian habitat assessment. These sites were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence. Big Hole River watershed 2003.

Max. possible score	**Parameter**	**DLNO 01**	**MCLN 01**	**SOAP 01**	**SOAP 02**	**CAMP 03**	**CAMP 02**	**CAMP 01**	**GROS 01**	**LOST 02**	**LOST 01**
10	Riffle development	10	10	10	10	7	9	4	9	7	9
10	Benthic substrate	10	5	9	9	4	5	5	3	7	7
20	Embeddedness	19	6	18	16	17	16	3	6	6	10
20	Channel alteration	20	19	20	18	15	12	12	18	14	14
20	Sediment deposition	19	11	18	10	9	14	3	7	15	10
20	Channel flow status	20	20	20	19	14	15	20	15	12	15
20	Bank stability	10/10	10/10	9/9	5/5	7/7	9/7	10/8	3/3	9/9	5/5
20	Bank vegetation	10/10	10/10	6/6	7/5	7/7	9/9	9/7	4/4	10/10	6/6
20	Vegetated zone	10/10	8/8	5/9	5/5	8/10	10/9	9/9	8/10	6/10	6/10
160	Total	158	127	139	114	112	124	99	90	115	103
	Percent of maximum CONDITION*	**99% Optimal**	**79% Optimal**	**87% Optimal**	**71% Sub-optimal**	**70% Sub-optimal**	**78% Sub-optimal**	**62% Sub-optimal**	**56% Sub-optimal**	**72% Sub-optimal**	**64% Sub-optimal**

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

Table 5c. Stream and riparian habitat assessment. These sites were assessed based upon criteria developed by Montana DEQ for streams with glide/pool prevalence. Big Hole River watershed 2003.

Max. possible score	**Parameter**	**PINE 02**	**FOX 02**	**WRMS 02**	**FRAN 01**	**SWMP 01**	**SWMP 02**	**BGHNF 01**	**BGHNF 02**	**MCVY 01**	**MCVY 02**	**FSHT 01**
20	Bottom substrate	18	17	20	16	10	15	16	15	3	11	20
20	Pool substrate char.	19	18	20	15	12	14	16	18	6	16	19
20	Pool variability	19	20	18	18	15	19	20	10	16	16	19
20	Channel alteration	20	19	20	20	18	20	20	18	20	20	20
20	Sediment deposition	17	19	20	10	15	14	12	15	10	10	15
20	Channel sinuosity	20	20	15	20	20	20	20	15	15	15	20
20	Channel flow status	20	20	13	20	20	20	20	16	20	20	19
20	Bank vegetation	8/8	10/10	5/5	10/10	8/8	8/8	10/10	4/4	9/9	8/8	9/9
20	Bank stability	6/6	9/9	4/6	10/10	8/8	7/7	10/10	5/5	8/8	5/5	6/6
20	Vegetated zone	9/9	10/10	2/9	10/10	10/10	10/10	9/9	3/3	10/10	10/10	10/10
200	Total	179	191	157	179	162	172	182	131	144	154	182
	Percent of maximum	**90%**	**96%**	**78%**	**90%**	**81%**	**86%**	**91%**	**66%**	**72%**	**77%**	**91%**
	CONDITION*	**Optimal**	**Optimal**	**Sub-optimal**	**Optimal**	**Optimal**	**Optimal**	**Optimal**	**Sub-optimal**	**Sub-optimal**	**Sub-optimal**	**Optimal**

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

Table 5d. Stream and riparian habitat assessment. These sites were assessed based upon criteria developed by Montana DEQ for streams with glide/pool prevalence. Big Hole River watershed 2003.

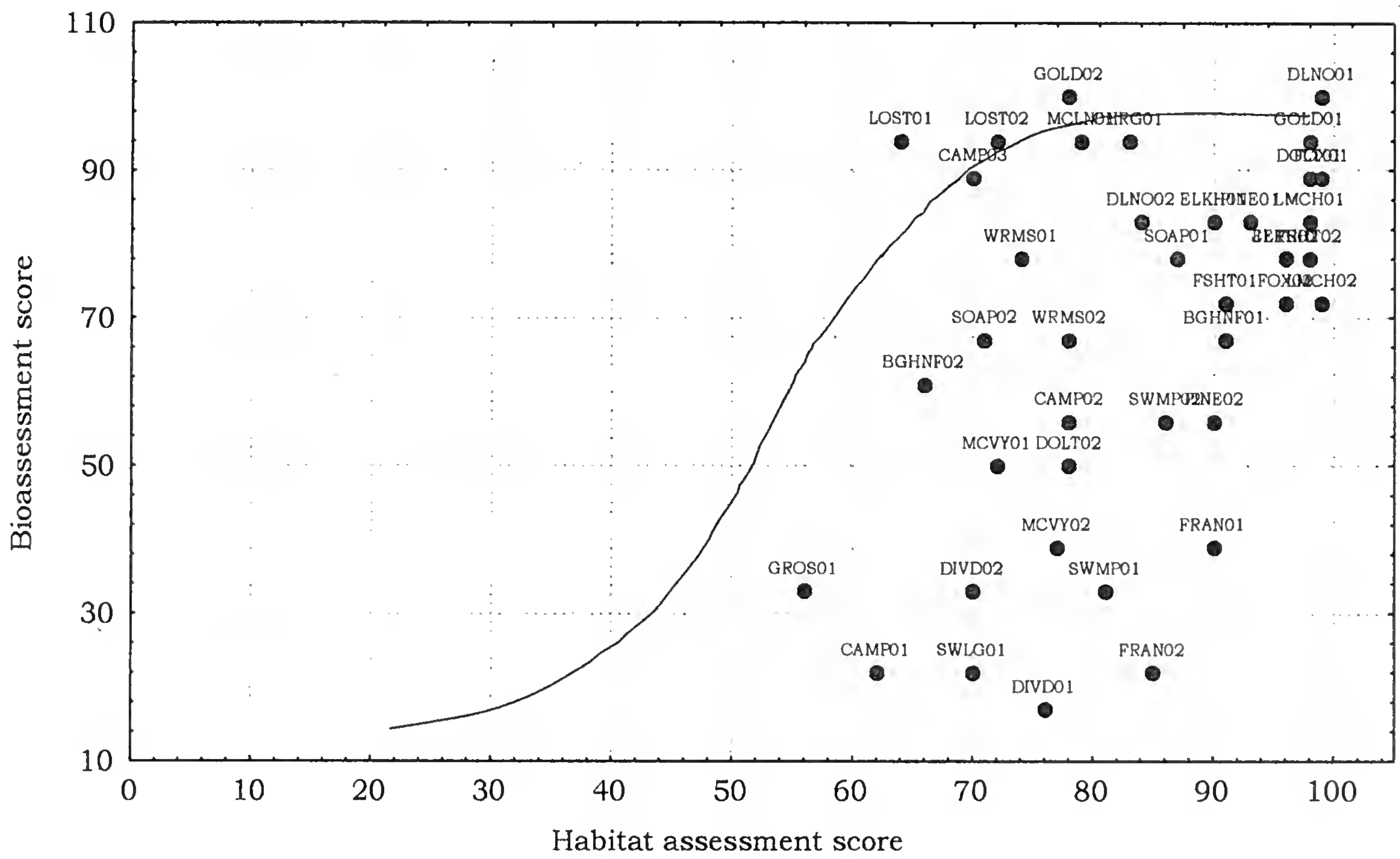
Max. possible score	Parameter	LMCH 01	ELKH 01	ELKH 02	GOLD 01	GOLD 02	DLNO 02	JERR 01	CHRG 01	DIVD 01	DIVD 02
20	Bottom substrate	20	19	20	20	12	16	19	16	18	15
20	Pool substrate char.	20	16	20	20	16	16	19	16	15	15
20	Pool variability	20	20	20	20	10	18	19	20	10	10
20	Channel alteration	20	20	20	20	18	20	20	20	18	20
20	Sediment deposition	15	12	15	20	15	16	18	11	6	11
20	Channel sinuosity	20	20	20	20	16	20	20	20	15	16
20	Channel flow status	20	20	20	20	20	15	20	5	15	6
20	Bank vegetation	10/10	9/9	10/10	9/9	8/8	7/7	9/9	9/9	9/9	9/9
20	Bank stability	10/10	8/8	9/9	9/9	6/6	9/9	9/9	10/10	9/9	9/9
20	Vegetated zone	10/10	10/10	10/10	10/10	10/10	8/8	10/10	10/10	9/9	4/8
200	Total	195	181	193	196	155	169	191	166	151	141
	Percent of maximum CONDITION*	**98% Optimal**	**90% Optimal**	**96% Optimal**	**98% Optimal**	**78% Sub-optimal**	**84% Optimal**	**96% Optimal**	**83% Optimal**	**76% Sub-optimal**	**70% Sub-optimal**

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

Habitat scores vs. bioassessment scores

When habitat assessment scores are plotted against bioassessment scores, the resulting figure provides an opportunity to evaluate the hypothetical relationship between habitat integrity and water quality. Both factors are critical and interactive determinants of the composition and functional integrity of aquatic invertebrate assemblages. Presumably, high quality habitat, in the absence of impairments to water quality, supports functional, diverse, and sensitive invertebrate assemblages; these are assemblages that attain high bioassessment scores. Barbour and Stribling (1991) have hypothesized that diminishing habitat quality should produce predictable diminishment of bioassessment scores, when water quality is not a further insult. Figure 6 is a plot of habitat assessment scores against bioassessment scores for the 2003 sampled assemblages of the Big Hole River watershed. The red line superimposed on the plot roughly represents the hypothetical relationship between habitat quality and biotic integrity given good water quality. In this model, symbols falling in the upper right area of the graph would represent sites with high scores for both bioassessment and habitat assessment; according to this model, these would be unimpaired sites both in terms of habitat integrity as well as water quality. Fourteen Big Hole River watershed sites fall into this approximate area of Figure 6. These are GOLD02, DLNO01, LOST01, LOST02, MCLEAN01, CHRGO1, GOLD01, CAMP03, DOLT01, FOX01, DLNO02, ELKH01, PINE01, and LMCH01. Some degree of habitat degradation is hypothesized for sites located along or near the downward progression of the red line, that is, when bioassessment scores are falling predictably with decreasing habitat scores. Sites falling into this region include WRMS01, SOAP02, and BGHNF02, and GROS01. When habitat scores remain high, but bioassessment scores are inordinately low, sites fall into the lower right hand area of the plot. According to the model, these sites support invertebrate assemblages that are impacted mostly by impairment to water quality. The plot in Figure 6 indicates that 22 sites fall into this area. They are SOAP01, FSHT02, JERR01, FSHT01, FOX02, LMCH02, WRMS02, BGHNF01, CAMP02, SWMP02, PINE02, MCVY01, DOLT02, MCVY02, FRAN01, DIVD02, SWMP01, SWLG01, CAMP01, FRAN02, and DIVD01.

Figure 6. Total bioassessment scores plotted against habitat assessment scores for sites in the Big Hole River watershed 2003. (Barbour and Stribling 1991).



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